PROTECTIVE FUNCTIONS OF FORESTS

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Summary.—The protective influence of forests on the habitat has been noted and recorded from the earliest times. During the past 100 years this has been the subject of observation and study. Naturalists are convinced of the beneficial effects of forests on the meteorological and hydrological conditions and of the large part that properly distributed and well maintained forests play in the well-being of rural and agricultural communities.

Careful experimental studies have indicated that the influence of forests on major climatic factors (especially rainfall) and on stream flow may have been overstated ; but generally speaking, the influence of forests is to mitigate and ameliorate excesses in the factors of the locality.

Historical evidence from many countries proves conclusively that the soil and physical conditions deteriorate with the destruction of forests or their degradation through excessive grazing or burning. Forest devastation may in time lead to the destruction of the physical bases of life, the spread of desert conditions, and the extinction of the local civilization.

Comparison of the protective efficiency of grassland, cropland and forest leads to the conclusion that the reactions of the forest on the climate and water regime of the locality are most constant and sustained.

By forest is meant a community of trees possessing a more or less continuous canopy with or without subordinate shrubby or herbaceous vegetation. Such a forest renders the air inside it cool and damp, protects the soil from direct exposure to the sun, retards the flow of air currents and promotes the accumulation of an absorptive and protective layer of leaf-litter and humus on the floor.

Forests are important pedogenic agents. The development of the soil and of the natural vegetation it supports are co-ordinate and interdependent. The moderating influence of forests on the temperature is distinctly noticeable. Trees act as pumps tapping the ground water from considerable depths and transfer it as moisture to the air, thereby increasing the relative humidity. Forests affect the ground water-table according to the initial nature of the soil and the topography : in dry soils and on slopes the water-holding capacity increases, but in ground liable to marshy or swampy conditions, forests tend to lower the water table and exercise a draining effect.

The influence of forests on rainfall has been much debated : while forests do not affect the primary meteorological causes of rainfall, they do have a noticeable effect on the incidence and distribution of local precipitation (as shown by observations in Ootacamund, South India, extending over a period of years).

The problem of soil erosion arises from the imprudent use of land and the indiscriminate destruction of forest cover. Planned afforestation has an important role in the rehabilitation of eroded lands. Narrow shelter belts of trees can afford effective protection against wind erosion. The solution of the problem of soil erosion lies in rational land use.

Forests perform a unique function of biological interest in affording shelter for wild fauna. They are also of considerable recreational value to man.

On purely commercial considerations alone forests may not be as profitable as other uses to which the land can be put, but the steady supply of forest products and the protective benefits of a forest cover are of paramount

importance. Such commercial considerations have no real place in the long term policies associated state ownership of forests.

Introductory.—The protective influence of forests on the habitat, not only immediately under their canopies but also for considerable distances around them, has been generally noted and recorded from the earliest times. The Rig Veda, which dates from about 3,000 B.C., contains, for example, the following observation : "During dry weather, columns of vapours collect over forests and spatial rays attract water-bearing winds over them". During the past 100 years the indirect benefits of forests have been the subject of observation and study and efforts have been made to measure precisely the reactions of the forests on the temperature, humidity and water regime of the locality. To foresters in general and to many naturalists it is almost an article of faith that the reactions of the forest on meteorological and hydrological conditions are both substantial and beneficial, and that the well-being of rural and agricultural communities is closely bound up with the preservation and proper distribution of forests.

Experimental evidence re-effects of forests on climate, etc.—Extravagant claims have occasionally been put forward as to the influence of forests on major climatic factors, notably rainfall. It was, for instance, claimed that a system of contour trenches recently dug around a hill in Bamiabaru in Bihar (India) had not only improved the quality class of the local *sal* forest but had also increased the local rainfall. The Indian Silvicultural Conference of 1939 investigated these claims in detail and came to the conclusion that "the data presented from Bihar do not justify the claims that contour trenches have so far had any appreciable effect on the climate or on the tree crop increment". The classical experiments of Engler and Burger at Emmenthal in Switzerland and the later experiments of Bates and Henry at Wagon Wheel Gap, Colorado, were attempts to assess precisely the role of forests on stream flow. The results of these experiments, especially those of the latter, suggested that the influence of forests on rainfall and water supply had been overstated. As a reaction ot the views of what may be called the orthodox school, it has been denied in some quarters that forests have any beneficial influence on rainfall or ground water supplies. Instances have even been cited from South Africa, Australia and elsewhere to show that afforestation resulted in the drying up of running streams and springs or that deforestation was followed by dry streams running or new springs flowing. The superiority of grassland over forest land as a soil and water conserving agent has been sought to be demonstrated. Engineers have maintained that structures such as dams, reservoirs, weirs, terraces, retaining walls and the like are more potent and more reliable than forests in controlling floods, regulating stream flow and maintaining water supplies. The literature in this controversy is extensive and growing apace. There is in fact a wide conflict of opinion and evidence as to the value and efficiency of the protective functions of forests.

Some of this conflict is of a partisan nature. And some of it is no doubt due to a failure to appreciate the ecological status of the particular forest in question and to the tacit but unfounded assumption that forests in all climates and terrains and in all stages of their succession have similar reactions on the local rainfall, humidity, water supply, temperature and atmospheric currents. Even in the field of soil conservation where the value of the forest is not seriously questioned, its efficiency must vary according as it is deep-rooted or shallow-rooted, deciduous or evergreen, coniferous or broad-leaved. To generalize from the results of observations or experiments in particular forests growing in specific conditions of climate and soil would be to repeat the mistake of the blind men in the fable, each of whom felt a different part of the elephant and described it variously as resembling a fan, a snake, a rope, a pillar, a wall and a spear. The forests of the world differ widely in form, structure, composition, and stage in succession, according to the climates and soils in which they grow and the biotic influences to which they are subject. The thorn and scrub forest of arid tracts is a very different thing from the tropical evergreen forest or from the coniferous forests of high altitudes and northern latitudes. The reactions of these widely differet formations on the local meteorological and hydrological conditions may naturally be expected to be various. There is therefore nothing illogical or surprising in the fact that conflicting observations have been recorded. It may,

however, be stated as a general proposition that insofar as forests which are the product of the combined effect of the climate and the soil react on these factors their influence is to mitigate and ameliorate excesses.

It would be unprofitable to attempt a review of the numerous experiments that have been made to assess the precise influence of the forest on humidity, rainfall, soil erosion, stream flow, etc. Most of these studies relate to European and American conditions. The conclusions arrived at are often discrepant and have done little to settle the old controversy to which reference has been made. It is doubtful whether the results arrived at under one set of conditions can be applied to another set of conditions even in the same general climate; the variables are so many. It is practically certain that conclusions based on European and American experiments and observations would need modifications before they could be applied safely to tropical and sub-tropical conditions.

Historical evidence of the evil effects of destruction of forest cover.—The historical evidence to prove the deterioration of soil and physical conditions which follows on the destruction of forests is overwhelmingly conclusive. Instances can be cited from nearly all heavily populated countries. The process of deterioration is usually very similar everywhere. Forests are cleared and burnt for the expansion of cultivation or pasture, for securing protection from the menace of wild animals, or for rapid (and improvident) exploitation of timber or other resources. In the vicinity of villages and settlements such forests as are not put to the axe are progressively degraded by excessive grazing, and burning for the sake of the tender grass which springs up with the first showers after the burn. Primitive methods of shifting cultivation are still practised involving stretches of good forest being felled and burnt for temporary cultivation which only lasts as long as the stored fertility of the forest soil can yield adequate crops. On vulnerable soils and sites, especially on sloping ground, these practices lead to cumulative erosion by wind or water, to the loss of the surface soil, to the deposition of erosion debris on fertile agricultural lands, to the reduction in the storage capacity of the soil, to the silting up of irrigation works, to the scouring of stream beds and to the spread of aridity. These consequences of forest devastation may in time become so aggravated that the physical bases of life are destroyed, the countryside turns into a desert and the local civilization becomes extinct.

These are not theoretical speculations. Mesopotamia which history tells us was a fertile and prosperous land in the time of the Babylonians, Assyrians, Chaldeans and Persians, is now virtually a desert. The story of Palestine and Syria is similar. Erosion and recurrent floods caused by extensive destruction of natural vegetation have impoverished China. The historian Alexandre wrote "In the reign of Augustus, the forests which covered the Cevennes were cut down and burnt in mass. A vast territory then presented a surface absolutely stripped. But a scourge, until then unknown, spread terror from Avignon to the Bouche-du-Rhone......this scourge is the mistral". The more recent experience of the United States of America of the bitter consequences of forest destruction is well known.

In pre-British times India was a well-wooded country. As a result of the rapid growth of the population under the Pax Britannica and of a faulty land policy adopted by the early British administrators, very considerable areas of woodland which were under private ownership were cleared or otherwise abused. The twin evils of erosion and aridity soon appeared in many parts of the country, the most spectacular effects occuring on the friable soils of the Pabbi hills and the Hoshiarpur Siwaliks of the Punjab. Sir Gerald Trevor quoted telling instances of the extent of the damage caused by a supine land policy, in his speech at the Empire Forestry Conference of 1935: "When the Emperor Jehangir built the castle of Nurpur for his Queen, Nur Jahan, the Light of the World, he writes in his memoirs that the forest was so thick that a bird could hardly spread its wings. But if you go to that place to-day, you will see nothing but a denuded hill country, with hardly more than a few tufts of grass and thorn bush, on which a few goats eke out a miserable existence. And that has happened in a period of not more than 300 years; in that time the dense forests which clothed the outer Himalayas have been reduced to a negligible amount. The Rajah of Kangra, himself the descendant of a very ancient line of kings, told me that they still point out

where the *machans* and shooting butts were placed in the days of Maharaja Sansar Chand. To-day the surroundings are as bare as this floor, there is hardly cover for a hare, leave alone a deer". Sir Gerald also showed the conference a photograph of what looked like an elevated tower, but was in reality the steining of an ancient well exposed by severe erosion of the land around it. Similar instances can be multiplied from the Etawah and Agra region of the United Provinces, the Chota Nagpur plateau in Bihar and the Nilgiris in the south. Historical evidence in India as elsewhere is unquestionably conclusive as to the disasters which follow the indiscriminate clearance of forests.

Protective efficiency of forests, grasslands and croplands compared.—Comparison are often made of the relative protective efficiency of grassland, cropland and forest, sometimes to the detriment of the forest ; balance sheets are prepared to indicate the net effect of these different types of vegetation on run-off, stream flow and underground water supplies by setting off the losses due to transpiration and evaporation from the soil and the leaf canopy (of intercepted water) against the rainfall received. These data are interesting as showing the order of magnitude of the quantities involved, but they are as a rule inconclusive as they do not paint the whole picture. In tracts where the climax vegetation is a form of forest, the vegetational alternatives to it are either agricultural crops or pasture. By hypothesis these latter forms of vegetation owe their origin and continuance to human intervention. This intervention may take various forms, such as clearing, burning, grazing, weeding and disturbance of the soil by cultivation. The management of grassland implies the recurring incidence of a rather intense biotic factor, namely, grazing by domestic animals, which is necessarily accompanied by a reduction of the density of the grass cover as well as a reduction in the infiltration capacity of the soil aggravated by the induration caused by the tread of animals. On steep slopes or loose soils these factors may initiate erosion. Burning, which is often associated with grazing, produces similar deleterious consequences. Whatever may be the theoretical value of grassland in protecting water supply and preventing erosion, as experimentally assessed, the nature of the use to which grassland is put involves risks which are only too often realised in practice. Under practical conditions, a well managed forest is a more reliable protective agent than a well managed pasture.

In most forms of agriculture a seasonal crop is raised, which occupies the ground for a few months at a time. There are therefore periods in the year during which the ground is bare of crops or the crop is too young to play an important part as a soil cover or as a hydrological agent. These periods often coincide with the seasons when heavy rain storms occur. But the reactions of the forest on the water regime and the climate of the locality are more constant and more sustained than those of other forms of vegetation. This is a point of importance. If the protective influence of grassland and cropland on the soil and on water supply and stream-flow, however great it may be under optimum conditions, is liable to serious fluctuation and diminution as a result of common practices associated with them, then the proper basis of comparison should be the protective effects *at their minima* under different vegetational covers. No doubt the protective efficiency of the forest also varies according as it is in leaf or not during periods of storms, but under tropical conditions it is unusual for all the trees in the forest to be leafless at the same time. Forest regeneration practices in protection forests do not as a rule involve the baring of the ground to any serious extent. Even in the leafless condition the forest still retains a considerable part of its protective power.

The attributes of a forest enumerated.—In discussing the protective functions of forests—a many-sided question—more satisfactory results will be obtained under present conditions by *a priori* reasoning, making full use of the broad findings of scientific research. In this argument we must confine our attention to only those types of vegetation, whether natural or artificial, which possess the commonly recognized attributes of a forest. That is to say, the forest is, for our present purpose, a community of trees of one or more species, with or without subordinate shrubby or herbaceous vegetation, extending over a considerable area and possessing a more or less continuous canopy. Such a formation differs from both grassland and cropland in that it functions actively both in the air and in the

soil at considerably greater distances from the surface level. The tree canopies may be elevated 100 feet or more and are rarely less than 25 feet above ground level. The root systems of the trees may penetrate to depths of 100 feet or more or even when superficial they may extend through the top 6 to 10 feet of the soil.

The effects of a forest cover.—The elevation of the canopy above ground level produces several effects. There is a variable but always appreciable depth of enclosed air within the forest, which is cooler and damper than the air outside the forest. The ground is shielded from direct exposure to the sun ; the temperature on the floor of the forest is consequently lowered with the result that evaporation from the surface is reduced, and the chemical processes involved in the break down of the leaf litter and the metabolism of the soil fauna and flora are slowed down. The flow of air currents is retarded by the obstruction of the tree trunks and foliage. Leaf litter and humus tend to accumulate to form a buffer between the surface of the soil and the air. This layer of litter and humus has a high absorptive capacity for water and protects the soil proper from the direct impact of falling rain whose force has already been broken by the interception of the canopy. The infiltration capacity of the soil is improved by the admixture of organic residues resulting from the breakdown of the leaf litter. The soil is protected from surface sealing such as would be caused by the direct impact of rain and the rapid flow of water along the surface. The channels and cavities left by decayed roots, and the burrows and holes made by rats, mice, voles, snakes, squirrels and earthworms (all of which find an ample food supply in the floor of the forest) enhance the downward trend of water, while the tree trunks, protruding surface roots, fallen twigs and branches, the leaf litter and the ground vegetation retard the surface run-off. Anything which delays surface flow must inevitably increase infiltration so long as the soil is unsaturated. In tropical climates the rate of breakdown of the leaf litter is rapid and appreciable layers of litter and humus cannot often be distinguished, especially in rather open mixed deciduous forests which are as a rule much subject to grazing. In such cases a form of low vegetation composed of grass and herbs is usually present and protects the soil in much the same way as a layer of litter, unless it has been destroyed by fire.

Reactions of the forest on the soil.—There is little controversy as to the protective and constructive effects of the forest on the soil. In discussing the reactions of the forest on the soil, it is useful to remember that the development of both the soil and the natural vegetation it supports are co-ordinate and inter-dependent, and that both are conditioned by the climate. Developmental succession of plant communities takes place as a result of the reactions of plant life on the soil through the addition of organic matter, the appearance of soil fauna and flora, the progressive modification of the micro-climate, the maturing of the soil by physical and chemical changes brought about by the plants themselves and the profound modification of the water regime of the soil. These reactions increase in scale and intensity as the vegetation advances to the woody and canopied stage and moves forward to the climatic climax. Forests are thus important pedogenic agents. Weathering, however intense and prolonged, can only produce comminuted rock particles ; and soils in the strict sense of the term, which are capable of producing food and sustaining life, can only be produced by a long occupation of the ground by natural vegetation of which the forest is the final and most powerfully reactive type.

The moderating influence of forests on temperature.—An obvious influence of the forest on atmospheric conditions is the effect on the temperature. This effect is due to both physical and biological causes. The screening action of the foliage prevents the sun's rays from heating up the forest soil to the same extent as in the open, and during night time prevents the rapid loss of heat by radiation. The leaves utilize the sun's rays for building up organic substances by photosynthesis. Heat is used up during transpiration. The moderating influence of the forest on temperature is due to these causes. The effects of the cooler air in the forest may be felt for some distance around it through breezes set up in calm weather by the interchange of cooled air from the forest with the warm air from outside during day time. The direction of these currents is reversed during night time with opposite results. The cooling effect of the forest is most marked in summer. This effect

may be felt for several hundred yards above the forest and has often been observed by airmen flying over forests.

Forest as a hydrological agent.—The function of the forest as a hydrological agent has evoked a great deal of speculation and controversy. A tree produces its substance by absorbing from the soil large quantitities of water containing minerals in low concentration, retains the minerals, uses some of the water for making carbohydrates with the help of the carbon dioxide of the air and for other purposes, and discharges by far the greater part of the water into the atmosphere in the form of water vapour by transpiration. It has been estimated that in order to produce a pound of dry substance the forest puts into circulation some 300 pounds of water. This means that an acre of forest with a current annual increment of 150 c.ft. draws about 1,000 tons of water from the soil and discharges it into the air as water vapour. Not only does the forest do this regularly from year to year without interruption, but it obtains its supplies of ground water not merely from the surface layers of the soil as in the case of grasses and field crops, but also from the subsoil often down to the water table. Trees thus act as pumps tapping the ground water to considerable depths and transferring it to the air. They make an important contribution to the total quantity of moisture in the air while at the same time causing an increase in the relative humidity by their cooling effect on the air. The air above a forest is often nearer saturation point than that above grassland, cropland or bare land, and the chances of condensation of water from clouds are correspondingly greater in the former. These chances are further increased by what is termed the orographical effect of the forest, this effect being due to the fact that the canopy functions as the surface cover forests ; since the canopy is some distance above the level of the ground, the forest behaves in much the same way as a low hill.

Forests and the water table.—The net effect of forest on the water table and on ground water supplies depends on the nature of the succession. If the land was initially rock or sand, the effect of the succession (lithoseral or psammoseral) would be to increase its water-holding capacity and to raise the water table. If on the other hand the land was first formed by the silting up of lakes, marshes, swamps, etc., the effect would be to drain the soil and lower the water table. A relapse to the original conditions may therefore be expected to take place in varying degrees, when forest is cleared, especially in the earlier stages of the succession. Thus in the famous Nilambur teak plantations, clearfelling of the teak has on certain sites led to the production of swampy conditions. In sites carrying a tropical evergreen forest profound changes in the moisture and other relations follow clearance that the secondary growth on such areas is generally deciduous owing to the drier conditions, and it may be a long time before the evergreen species resume possession of the ground. The felling of forest in dry and rocky areas is followed by an aggravation of the dry conditions.

The influence of the forest on the water table and ground water supplies also depends on the topography of the land. On slopes the forest tends to increase the ground water by retarding surface run-off, delaying the melting of snow and promoting infiltration. On flat ground these effects become much less important, and the water table may often be lowered by the sustained transpiration of the forest.

Forests & rainfall.—The influence of forests on rainfall has been subject of debate over a long period. The primary causes of rainfall are concerned with great currents of cold and warm air, the direction of trade winds and monsoons, the disposition of mountains and the amount of oceanic and continental evaporation. These factors operate on so large a scale that it is, to say the least, improbable that the presence or absence of forests, even of vast extent, could make any significant difference to the general rainfall of any tract of country.

An exhaustive enquiry was ordered by the Government of India in 1906 into the relation between forests and atmospheric and soil moisture in all the Indian provinces. A thorough analysis was made by the Local Governments of all available statistics of rainfall and of the level of underground water and flood crests. After careful consideration of the replies received from the Local Governments, the Government of India concluded

that the influence of forests on rainfall was probably small, but that the denudation of the soil, owing to the destruction of forests, might, as far as India was concerned, be looked upon as an established fact. As regards the effect of forest preservation on rainfall and the underground water supply, there was not sufficient information to justify any change in the principles on which the forest policy of the Government was based.

It is now generally accepted that claims that forests increase the general rainfall of a region to any appreciable extent are unsustainable. But to maintain that forests are altogether without influence on the incidence and distribution of rainfall even over limited tracts in their immediate neighbourhood would be to deny that the various physical and psychrometric reactions of the forest, to which reference has been made, have any effect on local precipitations. Such a view would be opposed to both reason and experience. The data given by Dr. Voelcker in his report entitled "Improvement of Indian Agriculture" are of great interest in this connection. These figures relate to Ootacamund and its neighbourhood on the Nilgiri hills, which before 1870 were nearly bare of trees "so much so that a photograph taken about that time has no resemblance whatever to the now thickly wooded station, the result of a large amount of planting by Government and by private individuals"........ "Taking all the months of the year except June, July and August (which are excluded because the rains of this period are not local in origin, but are those of the south-west monsoon and come from a distance), it was found that during the treeless period 1870–74 there was a total of 374 rainy days only, whilst during the wooded period 1886-90 there were 416 rainy days. Further than this, it was ascertained that the character of the rainfall had altered within late years, light and regular rain showers taking, to a great extent, the place of destructive occasional torrents. The agricultural importance of these facts is very great indeed". Dr. Voelcker's figures were brought up-to-date by the Inspector General of Forests in his evidence before the Agricultural Commission in India.

Period	*Rainy days excluding June, July & August*
1870–74	374
1886–90	416
1902–06	467
1918–22	481

He added "It thus seems clear that the number of rainy days in the Nilgiri Hills has increased with the increase of forests on those hills. On the 467 rainy days in 1902–06 rainfall was 165 inches ; on the 481 rainy days in 1918–22 the rainfall was 177 inches".

Nicholson quotes the case of Chota Nagpur to illustrate how deforestation may result in decrease of rain. "About 50 years ago when the district was well wooded instability rain was fairly frequent during the hot weather and at that time several tea gardens were opened up. During the last half century the forests (which were private) have been destroyed. There is no evidence to show that the monsoon rainfall has been affected thereby but so serious has been the decrease in instability rain that tea gardens can no longer in-fill and they are dying out".

Without claiming any influence for the forest on the great meteorological factors which primarily determine the rainfall of a region, it may be recognized that forests tend to increase local precipitation (*i*) to a slight and possibly measurable extent by their orographical effect, (*ii*) to a variable but significant extent by bringing about occult precipitation through condensation of moisture in the form of dew and mist, and (*iii*) to a substantial extent by causing in certain conditions afternoon showers known as instability rains. It is also very probable that forests exercise a beneficial influence on the distribution of rainfall.

Forests and the problem of soil erosion (1) by water and (2) by wind.—The problem of soil erosion, which has assumed menacing proportions in many countries including India, is primarily due to imprudent use of land ; forests have been destroyed without thought or plan, in the mistaken belief that they were inexhaustible. for the expansion of agriculture and pasture ; shifting cultivation is rife in undeveloped countries ; wasteful logging and exploitation without regard to the "possibility" of the forest and to regeneration have been practised in some highly developed countries. The damaging effect of fires on the protective functions of the forest has been recently demonstrated by experiments in Central California by the U.S. Forest Service. Excessive grazing has a similar effect. Accelerated erosion is therefore an entirely man-made problem, and its prevention is consequently wholly in his hands.

Under natural conditions, the ground is always covered by a mantle of vegetation, except where the conditions are so extreme as to exclude vegetation. Over most parts of the earth, wherever human settlements exist, the natural climax vegetation is usually a form of forest. The progress of civilization through its nomadic, pastoral, agricultural and industrial phases has been marked by a progressively intensive and extensive destruction of the natural forests of the world. A stage is however frequently reached when the unchecked destruction of forests by man recoils on him ; outraged nature has often taken its revenge by making it impossible for man to continue to subsist in the tracts devastated by him. The protective value of well-managed forests is now realized in most countries. But man must live and he needs land to grow his food and graze his cattle and it is clearly impossible for all the land or even any large part of it to be retained under forest. The solution of the problem lies in a rational use of land.

In a state of nature the forest affords complete protection against all forms of erosion other than geological erosion. Agriculture inevitably implies the total rejection of the protective effects of natural vegetation, since it involves frequent disturbance of the soil by tillage and the replacement of the natural vegetational cover by an artificial grouping of short-lived food and/or commercial plants. In the nature of things agriculture cannot play a constructive or defensive role so far as the soil is concerned without the aid of costly special techniques of cultivation, of engineering measures and of the protective function of suitably disposed forests.

In most populous countries the forest receives the lowest priority in land use, being simply relegated to residual sites not required for cultivation or grazing. As a general proposition it is of course proper that agriculture and animal husbandry should come before forestry. But this principle requires qualification if its blind application is not to lead to the jeopardy of the very interests it seeks to promote. On certain types of land the right use is not agriculture but forestry. As a general rule, cultivation should be excluded from slope exceeding 20%, where erosion is a danger to be guarded against ; such slopes should be placed under grass or forest. On slopes exceeding 30% the land should be retained under its natural cover, which is generally forest, and grazing should be excluded. Even on gentle slopes it may be expedient to keep the land under complete or interrupted natural cover, if the soil or rock formation is highly erodible or the locality is subject to storms of great intensity. These general recommendations will of course need modification according to local conditions.

Forestry has an important part to play not only in preventing erosion but also in rehabilitating eroded lands. This is usually an uphill task, as in most cases the top soil has probably been lost, and the process of recovery is slow and expensive. There is, however, no practicable alternative to afforestation in such cases, and success depends on the rigorous exclusion of grazing and fire and, in aggravated cases, on the adoption of water conservation measures such as contour trenching and bunding.

While the influence of forests on the water regime of a tract and on stream flow and flood control is most pronounced in hilly areas, their effect in breaking the force of winds and arresting wind erosion is most marked on extensive featureless plains. The action of shelter belts is essentially to present a mechanical obstacle to the free sweep of wind currents so as to retard their velocity and deflect them upwards. The result is to minimize their desiccating effect on the crops to the leeward of the belt and their power of lifting soil. Any solid obstacle would produce the same results, but a front of tree growth is cheaper and more effective in that it permits the passage of air gently through, while exercising a screening action on it. Quite narrow widths of belt are adequate for the purpose ; in the U.S.A. a width of 8 rods is recommended. Shelter belts one chain wide have been found to be effective in preventing sand drifts from the dry bed of the Hagari river in South India, although it is likely that an increased width would produce additional benefits by humidifying the air through transpiration, resulting in reduced transpiration losses of the cultivation leeward of the belt. Where mortality of field crops by desiccation is a danger to be feared and countered, it would be necessary to secure the biological benefits of the forest, in addition to the mechanical protection afforded by it ; this could be done by creating shelter belts of

considerable width and extent. In general, however, the height of the shelter belt is more important than its width, provided it is dense enough and the trees are in leaf during the critical period of wind storms. The distance to which the protective effect of shelter belts extends has been variously estimated at from 20 to 30 times the height of the belt.

Forests as the home of wild life.—One of the unfortunate results which follows the destruction of forests is the extinction of wild life associated with them. In countries like England where the original natural vegetation has been almost completely destroyed wild animals have either entirely disappeared or are rare curiosities. In many cases in India the burning and felling of forests are expressly undertaken for the purpose of ridding the locality of dangerous carnivores such as tigers and panthers, or pests to field crops such as pigs, deer, *sambhar* and elephants. While it is true that agriculture and village communities must be made safe from the depredations of wild animals, hardly any intelligent person would view with equanimity the total disappearance of wild life from his country. An India without tigers and elephants would be unthinkable. And yet their numbers have dwindled considerably during the last century. The shrinking forests of the country are now their last refuge. If care is not taken to preserve the forests and protect wild life from the unscrupulous *shikari*, some of our rarer animals will become extinct, as the lion and the rhinoceros have almost become. Economic justification for the preservation of wild life is not always easy to produce, but even on economic grounds insectivorous forest birds pay their way by keeping insect pests of agricultural crops in check. Elephant capturing operations are a regular and lucrative activity of Indian forest departments. In sheltering wild life the forest performs a unique function of great biological interest.

The recreational value of forests.—Finally a word may be said about the recreational value of the forest. Quite apart from the freshness and purity of the forest air so greatly valued by picnicking town-dwellers, the forest makes an instant appeal to a deep-rooted aesthetic and spiritual sense in man. Trees, especially *en masse*, are objects of beauty. The forest is not just a collection of trees, shrubs and herbs. Together with the animal life which it harbours, it constitutes an organic entity with a life and laws of its own, gay and cheerful or dark and menacing by turns but always mysterious. A holiday spent in the forest brings peace and refreshment to tired and harassed men. The recreational value of a forest is not the least of the benefits it confers on men.

Conclusion.—Even in many aspects of productive forestry, rigidly conventional considerations of profit and loss, returns on invested capital and the like may be out of place. If the question were reduced to the simple terms of whether a particular piece of land would *pay* more under field crops or pasture, or as building sites or an amusement park or under a host of other profitable but unproductive land uses, the answer may often go against forestry. If purely commercial considerations of profit and loss are allowed free play, it may well happen that existing forests may be clear-felled or over-felled to take advantage of a period of high prices, or that forest land may be converted to other temporarily more profitable uses. The result will be a reduction in the supply of timber, firewood, and other forest products, with unhappy repurcussions not only on the direct consumers but also on the supply of raw material to wood based industries. To this should be added the loss of the literally inestimable protective benefits of forests. These dangers are real and inevitable under a system of private ownership of forests and furnish the raison d'etre for state ownership of forests in all progressive countries. Under state ownership the economics of forestry are radically transformed. There need no longer be any need to show immediate profits at any cost. The steady employment that ordered forestry assures, and the full and uninterrupted supply of wood and forest products to the public and wood using industries are factors on the credit side of state forestry. The protective benefits of forests are thrown in for good measure and in defending the land against the evils of erosion, aridity and climatic excesses, forests perform services no less valuable and no more expressible in terms of money than those rendered by the defence forces of a country.

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STUDIES ON ADHESIVES

A preliminary note on adhesives from the proteins of the seeds of *Terminalia belerica*

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PART XV

In previous parts of this series (published separately) work on the development of adhesives from oilcake proteins, seeds of sunn hemp, *Lathyrus sativus*, etc., have been described. This part deals with adhesives developed from the proteins of the seeds of a forest tree, viz., *Terminalia belerica*. This is a tree which seeds prolifically and is distributed over a wide area of the country. The fleshy portion of the fruit is a good source of tannin but the seed which forms about 10% of the fruit is now a waste product. Therefore, the seed was taken up for investigation.

Proximate analysis of the seed.—The seed was found to contain 38.8% of oil. Proximate analysis of the oil free residue of the seed gave the following values : Moisture 10.61% ; Ash 3.33% ; Ether extractives (moisture free basis) 5.70% ; Carbohydrate and fibre 50.13%. It will be seen that the oil free residue of the seed contains about 35% of protein.

Distribution of nitrogen in the defatted meal.—Extraction of the defatted meal with different solvents in succession gave the following figures for the distribution of nitrogen : water

12.2% ; 4% sodium chloride 72.57% ; 80% alcohol 2.40% and 0.4% sodium hydroxide 10.72%. The protein is mostly globulin in character with a small percentage of guletelin.

Preparation of the protein for adhesives.—For work on adhesives the protein was prepared as follows : The oil free meal of the seeds was ground fine and extracted with 0.4% sodium sulphite in a large glass vessel with continuous stirring for 1–2 hours. Each batch was extracted twice. At the end of the extraction period the meal was allowed to settle and the extract syphoned off. This was first filtered through cloth and then centrifuged. The protein in the clear extract was precipitated by passing SO_2 through it, allowed to settle and centrifuged. The precipitate so obtained was dried in an internal fan-kiln at about 50° C. and 60% R.H. in shallow trays. This was then finely powdered and stored in a bottle till required for use. Analysis of the protein so prepared gave the following figures : Moisture 6.97% ; Ash 1.1% ; Ether extractives 0.69% and Nitrogen 15.1%.

Formulæ studied and preparation of the plyboards.—As the quantity of protein available for the studies was small, only a few formulæ could be studied. Both cold press and hot press formulæ were investigated. The adhesive prepared from the protein according to the appropriate formula was applied to the veneer and pressed under the required conditions of pressure and temperature. (In most of the cases 2 boards were pressed).

Cold Press formulæ.—The following formulæ usually used with casein were tried :—

C_1 *Protein-Lime-Sodium Silicate formula.*

Protein	..	100 parts
Water	..	200 ,,
Lime	..	20 ,,
Water	..	100 ,,
Sodium silicate (water glass)	..	56 ,,
Copper sulphate	..	2 ,,
Water	..	30 ,,

C_2 *Protein-Lime-Fluoride formula.*

Protein	..	100 parts
Water	..	200 ,,
Sodium fluoride	..	12 ,,
Water	..	50 ,,
Lime	..	32 ,,
Water	..	100 ,,

C_3 *Protein-Lime-Caustic Soda formula.*

Protein	..	100 parts
Water	..	200 ,,
Sodium hydroxide		11 ,,
Water	..	25 ,,
Lime	..	20 ,,
Water	..	50 ,,

The boards were pressed at about 200 lb./sq. in. and kept under pressure for about 24 hours after which they were removed and allowed to condition in the air for about a week before testing. The results of glue adhesion tests are given below :

Formula	Moisture content %	Glue Adhesion Tests			
		Dry Tests		Hot Wet Tests	
		Failing load lbs.	Glue failure %	Failing load lbs.	Glue failure %
C_1	11·21	127	78	65	98
C_2	12·2	131	94	24	100
C_3	10·96	240	16	154	100

The results obtained with formula C_3 were satisfactory.

Hot press formulæ.—Several hot press formulæ using lime were tried.

The formula employed was :—

Protein	..	100 parts
Water	..	200 ,,
Lime	..	X ,,
Water	..	100 ,,

Various percentages of lime were tried and the boards were pressed at 280° F. and 250 lb./sq. in. for 12 minutes (for one 3/16″ board). The results were as follows :

Concentration of lime %	Moisture content %	Glue Adhesion Tests			
		Dry		Hot Wet	
		Failing load lbs.	Glue failure %	Failing load lbs.	Glue failure %
		Zanthoxylum rhetsa			
4	8·57	238	44	89	84
		Mangifera indica			
..	8·31	141	0	98	97
		Zanthoxylum rhetsa			
6	8·0	231	33	90	98
		Mangifera indica			
6	8·51	215	65	73	98
		Bombax malabaricum			
7	7·25	122	99	69	100
		Zanthoxylum rhetsa			
8	7·7	189	7	0	100
		Mangifera indica			
8	7·4	189	93	0	100

Lime concentrations above 6% appear to be detrimental.

As the wet strengths were not very satisfactory the addition of copper sulphate was tried, the formulæ used being :

Protein	..	100 parts
Water	..	200 ,,
Lime	..	4 ,,
Water	..	50 ,,
Copper sulphate	..	X ,,
Water	..	50 ,,

The results of glue adhesion tests are given in the Table below :—

Copper sulphate used %	Moisture content %	Glue Adhesion Tests			
		Dry		Hot Wet	
		Failing load lbs.	Glue failure %	Failing load lbs.	Glue failure %
		Zanthoxylum rhetsa			
0	9·63	238	44	89	84
2	8·75	361	10	105	100
4	9·82	247	60	153	93
6	7·36	311	3	152	100

As can be seen, addition of copper sulphate increases the hot wet strength.

Formulæ incorporating formaldehyde.—In previous parts of this series various protein-formaldehyde dispersions as adhesives developed in this laboratory have been described. In view of the satisfactory results obtained in most of the cases the possibility of developing similar adhesives was also tried with this protein. The formaldehyde figure of the protein was determined as given in Indian Forest Leaflet No. 16. The results obtained were as follows:

Period of reaction in days ..	1	2	3	7
% formaldehyde bound ..	1·67	1·97	2·1	2·2

The quantity bound is similar to that obtained with ground nut protein. Protein-formaldehyde dispersions similar to those described in Indian Forest Leaflet 16 were prepared the formulæ employed being :

Formula	A	B
Protein	100 parts	100 parts
Borax	10 ,,	10 ,,
Liquid Ammonia (Sp. gr.)	32 ,,	32 ,,
Formalin	100 ,,	48 ,,
Water	Sufficient to make glue of satisfactory consistency.	

The veneers were coated with the dispersion and after drying in the air were pressed at 280° F. and 250 lbs./sq. in. for 11 minutes (for a 3/16″ thick board). The results of glue adhesion tests carried out on the boards are given in the Table below :

Formula	Moisture content %	Glue Adhesion Tests			
		Dry		Hot Wet	
		Failing load lbs.	Glue failure %	Failing load lbs.	Glue failure %
A	7·4	295	43	136	72
B	8·4	346	10	129	100

The results were satisfactory.

Other formulæ incorporating various forms of formaldehyde used were as follows :

P. *Formaldehyde-Chromium Trioxide formulæ.*

Protein		100 parts
Water	..	20 ,,
Ammonia	..	3 ,,
Chromium trioxide		2 ,,
Water	..	40 ,,
Formaldehyde (40%)		5 ,,

Q. *Protein-Paraformaldehyde formulæ.*

Protein	..	100 parts
Water	..	200 ,,
Ammonia	..	3 ,,
Paraformaldehyde		10 ,,
Water	..	50 ,,

R. *Protein-Hexamine-Ammonia formulæ.*

Protein	..	100 parts
Water	..	200 ,,
Ammonia	..	2 ,,
Water	..	20 ,,
Hexamine	..	15 ,,
Water	..	30 ,,

S. *Protein-Hexamine-Lime formulæ.*

Protein	..	100 parts
Water	..	200 ,,
Lime	..	5 ,,
Water	..	50 ,,
Hexamine	..	20 ,,
Water	..	50 ,,

The boards were pressed at 280° F. and 250 lb./sq. in.

The results of glue adhesion tests were as follows :

Formula	Moisture content %	Glue Adhesion Tests			
		Dry		Hot Wet	
		Failing load lbs.	Glue failure %	Failing load lbs.	Glue failure %
P (1)	7·5	301	33	103	94
Q (1)	8·8	252	30	148	65
R (1)	7·3	171	0	0	100
S (1)	11·1	224	86	90	99

Only formulæ P and Q appear to be satisfactory. The borax formaldehyde dispersions are to be preferred.

The above results indicate that satisfactory adhesives both cold pressed as well as hot setting could be developed from *Terminalia belerica* seed proteins. As the quantity of protein available was small the best formulæ and conditions of pressing, etc., could not be standardized. With further work it is possible that still better results can be obtained. As and when more protein is available it is proposed to extend the present experiments.

SEASONING PRACTICES AND MANUFACTURING OPERATIONS FOLLOWED BY VARIOUS WOOD WORKING INDUSTRIES OF U.S.A., CANADA AND ENGLAND

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PART I

Summary.—The article describes the method of handling sawn material in the timber yards and manufacturing concerns of U.S.A., Canada and England. It states that every timber industry of the West has developed a technique of its own for seasoning wood, which it finds the best and cheapest for its requirements. The details of the method of seasoning wood for shuttles and bobbins are given, along with a brief description of the manufacturing operations of the same.

General.—The general principles of seasoning wood are the same for all purposes, but every timber industry of the West has developed a technique of its own, which is the cheapest and the best for its requirements. Unseasoned wood is seldom used for the manufacture of

any wooden store. Even the stockists of timber as opposed to the manufacturers of wooden goods, who sell sawn timber for domestic use, have elaborate arrangements for the seasoning of wood. They would not send out unseasoned stock into the market for fear of getting a bad name. The public is conscious of the advantages of seasoned wood, hence none would buy unseasoned timber. The Government Departments would not accept timber which is not certified to have been properly dried. During the War period the Board of Trade in England passed the Kiln Drying Control Order with the same object.

The development of seasoning in the Western countries is partly due to the high standard of living and general education, amongst the public, and partly due to the existence of a number of kiln equipment makers, who do a lot of propaganda work in favour of seasoning, visit the sawmills and wood working concerns, and provide efficient kiln installation and repair service to the timber trade.

In most of the wood working factories using hardwood species, the bulk of timber comes as sawn and partially air seasoned planks and scantlings from the sawmills, some of which are situated near the forest. A small proportion of timber comes as logs which are sawn in the sawmill attached to the factory. The timber stockists who sell sawn timber for domestic use get the wood either as logs or as sawn planks, or partly as logs and partly in the form of sawn material, the practice varying in different timber yards. Whatever the form in which the wood is received by the stockist or by the manufacturer, it is properly seasoned and adequate arrangements for seasoning wood exist in every timber yard or factory.

Method of handling and stacking.—In large timber yards and big factories various mechanical means are adopted for the movement of timber from one part of the yard to another. The yard is usually laid with tracks on which trolleys loaded with timber move. The use of transfer trucks for moving loaded trolleys from the air seasoning yard into the seasoning kilns is very common. The transfer trucks are usually provided with their own motive power derived from petrol or diesel engine.

The timber comes to the factory either in railway wagons or in big motor trucks. The logs are unloaded by cranes. In many plywood factories the logs are mechanically moved from the unloading platform into the factory. This is done by placing the logs one by one into a big metal groove at the bottom of which there is an endless moving chain. The movement of the chain moves the log in the groove till it reaches the destination.

The planks are usually unloaded into trolleys which move on rails from one part of the yard to another. In certain factories the planks are dropped one by one on a moving endless wide belt (automatic conveyor) which takes them on to the end of the yard, where they are made to drop as they come, on the waiting trolley. As one trolley gets filled up, it is moved on, and another trolley takes its place.

The unloading of planks which come in motor trucks is either done in the usual manner when the planks are unloaded into the trolleys, or the timber is removed in 'packs' by means of motor driven lift trucks. These lift cars are fitted with two horizontal bars to serve as base for the pack ; the base is capable of moving up and down along two vertical guides for lifting and lowering the stack (pack). The system of "pack handling" of sawn material is very common in the American timber yards, and it has now been introduced in some big timber yards of England also. Even big stacks of planks piled on crossers are lifted and removed in this way from one part of the yard to another undisturbed.

The stacking of planks and scantlings for air or kiln seasoning is usually done by manual labour. The stacks are very carefully made. Sometimes spacing racks are used for keeping the vertical alignment of crossers. In some of the big timber yards of America where very high stacks are made, the trolleys on which stacking is done are capable of vertical movement. As the stacking progresses, the metal platform carrying the trolley is made to descend slowly below the ground level in an underground cellar. During the course of stacking the top of the stack is kept at breast height all the time to facilitate stacking. When the stack has been completed, which sometimes may be as high as 30 feet, the platform with loaded trolley is raised to the ground level, and the trolley is moved on to the seasoning yard with the help of a transfer truck. In some factories large trolleys loaded with timber stacks are mechanically raised from ground floor to the first or

second floor in the factory, where the planks are removed one by one from the top of the stack, to be fed in the planing machine. The timber once piled on trolleys with the help of crossers is not unloaded till the whole cycle of various processes of air and kiln drying, and conditioning has been completed. This results in considerable saving of time and labour.

For most purposes in which hardwoods are used, the timber is first partially air seasoned and later kiln dried. The air seasoning yards are usually open, though some yards are partly open and partly covered over with a roof. After kiln drying the timber is either used or stored in sheds. The seasoned timber is never left in the open. The kilns used are of the modern internal fan type, though in some factories Thermal Circulation kilns, Grand Rapids kilns, External Blower and Bachrich kilns are also used. The modern kilns are fitted with automatic temperature and humidity recorder controllers, carrier doors, transfer trucks, etc.

It may be remarked that the big manufacturers of wooden stores have their own seasoning installations suited to their needs, in their own factories, but the demands of small manufacturers for seasoned timber are also conveniently met with. There are several sawmills and big stockists who keep stock of sawn and seasoned material in the form of half wroughts or dimension stock to meet the requirements of small scale manufacturers, who are their regular customers. One does not fail to notice that development of sawmilling and seasoning are two important pre-requisites for the development of timber industries.

The following information with respect to the seasoning technique, the manufacturing operations and the treatment of timber adopted in U.S.A., Canada and England, by different wood working industries, such as manufacture of shuttles, bobbins, various kinds of handles, golf clubs, flooring strips, furniture, aircraft propellers, barrels, plywood, bent wood articles, battery separators, and pencils, will be of interest.

(a) Shuttles

General.—The jute mill and the woollen mill shuttles which are comparatively bigger in size are made from persimmon (*Diospyros virginiana*) ; cornel wood (*Cornus florida*) is used for shuttles for cotton textiles, coarse cloth and silk.

The shuttle makers usually receive the timber from the sawmills in the form of blocks of different sizes with the ends coated with wax. The processes of conversion of timber, and coating with wax to prevent end splitting, partial air drying, and the selection of blanks are carried out by the sawmillers, who supply the partially seasoned and selected blocks to the manufacturers of shuttles according to the agreed specifications.

Seasoning in sawmills.—The timber (persimmon and cornel) comes to the sawmills as logs, which are cross cut into smaller bolts, say 4′ to 6′ in length. The bolts are sawn into flitches about 2″ in thickness. The flitches are further sawn into squares from which shuttle blocks are obtained by cross cutting into suitable lengths. The blocks with defects are rejected at this stage, and the ends of sound blocks are immediately dipped in molten paraffin wax to prevent end splitting in wood during seasoning.

The green shuttle blocks are then stacked in the open crib manner in the air seasoning sheds. The stacks are covered over with hessian cloth for the first fifteen days to reduce the rate of drying. Later the hessian cloth is removed and the air seasoning is continued for about three months. At this stage the blocks are sent to shuttle manufacturers. In rare cases the seasoning of air dried blocks is completed in kilns in the sawmills. The shuttle blocks are never kiln dried green from the saw.

Seasoning in shuttle factories.—The shuttle blocks have about 25% moisture content when received in the factory. They are further dried in hot air rooms to about 10% moisture content by the shuttle manufacturers. The hot air room* is an ordinary masonry room fitted with wooden or metal racks. It is usually heated by steam pipes placed below the racks or distributed in the room in an irregular manner, so as to raise the temperature of the air inside the room to about 100° F. No attempt is made to regulate the humidity, which remains at about 40% to 45% without any control. The shuttle blanks are stacked in the open crib manner in the racks to complete the drying

*The Forest Research Institute has also designed cheap types of Hot Air Rooms, heated by steam or by smoke gases coming from a wood burning furnace, for seasoning of shuttle and bobbin blanks, the details of which can be had from the Officer-in-Charge, Wood Seasoning Branch, Forest Research Institute, New Forest P.O., Dehra Dun., U.P.

operation which takes about three weeks. Usually the racks are three deck high and they are arranged in long rows about 3′ apart. The racks are provided with expended metal, wooden strip, or wire gauze base for holding the blanks to be dried. After seasoning has been completed the blocks are stored in close heaps in the godowns till needed for manufacture.

Manufacture.—The machinery and the manufacturing technique for shuttles are more or less standardized. Several shuttle makers in India have got the full set of machinery used for shuttle making.

The manufacturing operation starts with making a hole at each end of the block to take in the metal tips. Later a circular cut is made round these holes for taking copper springs. After these operations have been carried out, the copper springs, one on each end, are inserted in the round cuts, then the metal tips dipped in glue are fixed in the holes. Circular fibre washers are usually put in between the metal tip and the wood. The shuttle block is then rounded at the ends, scooped from the interior, holes bored, eyes put in, the metal fittings fixed, sand-papered and finished.

The finished shuttles are pressure impregnated with linseed oil at 25 lb. per sq. inch pressure for 15 minutes, removed, hung in the air for a few minutes, sand-papered, cleaned and packed.

(b) Bobbins

General.—Birch and maple are commonly used for bobbin making but maple is preferred. The bobbins are of various sizes. Probably the largest size of bobbins used in jute mills have a barrel, 18″ in length and 3″ in diameter. The flanges of these bobbins are 16″ in diameter and 1″ thick, made up of 7 plies.

Seasoning.—Usually the bobbin factories receive the timber in the form of sawn planks and scantlings which get partially seasoned during transit. On arrival in the factory, the wood is cut into the blanks for the manufacture of various types of bobbins. The blanks meant for the barrels of built up bobbins and for the tubes and pirns are bored and rough turned. The pre-bored rough-turned half-wroughts as well as cut-to-size blanks for the flanges are loosely bundled in gunny bags, which are removed to a hot air room and placed in racks for completing the drying operation. It is estimated that the moisture content of timber at this stage is about 35% to 40%. In some factories the partially seasoned blanks are heaped in an irregular manner in the racks in the hot air room for drying.

The hot air room is of the same type as the one used for drying shuttle blanks described under (*a*) above. The seasoning of bobbin blanks is completed in about 3 weeks at 100° F. In certain factories there are a number of hot air rooms kept at two or three temperatures. The blocks of wood are shifted from one room to the next, kept at slightly higher temperature, till the blanks are seasoned.

Manufacture.—The manufacture of bobbins is also a standardized process. Almost the same technique is adopted by different makers. The partially air seasoned blocks are first sorted for defects, the selected pieces are bored and rough turned. Later their seasoning is completed in hot air rooms, after which they are finally bored and turned to exact size. The fixing of metal parts, and various other small operations are then carried out. The finished bobbins are then sand-papered, given two or three coats of varnish, which is allowed to air dry and then packed.

[*To be contd.*]

EVERGREEN, MONTANE FORESTS OF THE WESTERN GHATS OF HASSAN DISTRICT, MYSORE STATE

A Contribution to the Ecology, Plant Geography and Silviculture of the Western Ghat Forests of Mysore

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Summary.—This paper deals with one of the most exhaustive ecological *cum* floristic *cum* silvicultural studies undertaken on the evergreen mountain forests of the Western Ghats in Mysore state or probably even beyond it. It has brought out the reaction upon one another of the various components forming the ecological complex of factors reigning in the forests of the tropical zone in general and of the evergreen forest in particular, and brings out clearly how these factors control and decide within the forest the kind, distribution, quality and climax form of the associations of trees, shrubs, herbs or other minor forms of the vegetable kingdom, be they phanerogams or other lower ones, and how the stature and distribution of each and every individual can be accounted for logically by a close study of the inter-action of the ecological factors from spot to spot.

The evergreen forest, though apparently more uniform in its constitution than the other kinds, is actually more diversified in its form and composition than any which nature has produced in the tropics : there is probably no place on earth where plants are so closely situated physically, yet so diversified or separated or rendered complex in their ecological bearing and structure as in this evergreen forest ; and there is probably no forest on earth which excels the moist, tropical, mountainous evergreen in its accumulation of the natural habitats both in their number and variety.

The ghat forests of Hassan district remained, till very recently, more or less a "*terra-incognita*" on account of their inaccessibility and the want of a market for the timbers which form the bulk of the growing stock. It was, however, well known for a long time, that they contain a large number of ghat timbers, some of which had not been correctly identified, while the distribution of most within the forest zone was yet unknown ; nor were these works of urgency and importance, because there existed very limited demand for the timbers. The chief impediment in the way of intensive forest explotation and popularizing the timbers was the difficult nature of the ghat country and the consequent long leads to the markets and the unrenumerative exploitation. The starting of a new Plywood Factory in Mysore opened a market for the softwoods in the forests, and the following study was taken up by the author in connection with the preparation of a Working Scheme to regulate forest exploitation.

SECTION 1. *Name, situation and area of the forests.*

1. The five state forests which form the subject matter of this article are known under the names KABBINALE, KENCHANKUMRI, KAGNERI, KEMPHOLE and BISLE. They occupy mostly the slopes of the Western Ghats facing the Arabian Sea at the southern end of that range of mountains within Mysore territory. They cover a total area of 43,373 acres as detailed below :—

Kabbinale State Forest	..	16,954.7	acres
Kemphole State Forest	..	8,371.4	,,
Kenchankumri State Forest		2,263.2	,,
Kagneri State Forest	..	7,033.7	,,
Bisle State Forest	..	8,750.0	,,
Total	..	43,373.0	acres

All the forests form part of Manjarabad tāluk, Hassan district.

2. The area is bounded on the North by the district boundary of Kadur district, on the East by a number of cardomom, tea and coffee estates, on the South partly by Yedavanad of Coorg and Subrahmanya Reserve of South Kanara district and on the West by the reserved forests Shiradi, Shisla, Kombar and Bhaginahole of the same district. It includes the catchment areas of the streams Kabbinale hole, Kemphole and Addhole all of which unite in the plains of South Kanara to flow into the river Netravati which discharges into the Arabian Sea.

SECTION 2. *Physical features of the region*

3. The country is mountainous, the general drainage being westward to the Arabian Sea. The ground generally slopes steeply, often precipitously. The forest streams, a large number of which are perennial, have scoured deep down into their beds forming steep, often nearly vertical, walls standing several feet high. Small leaps of water, locally called "*Abbulu*" are found, especially on the Kemphole, Addhole and some of their tributaries.

4. The highest point is Jenkalgudda at the northern tip of this region in Kabbinale forest, (4,553 feet high) whose bare peak towers picturesquely above the surrounding country, while the lowest altitude, of about 450 feet, is found in two places, one at the south-western corner of the State on the Meruthi-hole in Bisle forest and another on the Kabbinale-hole at the south-western tip of the forest bearing the same name, also adjoining the Madras frontier.

5. The economic value of the forests and lands of the Hassan Ghats has been low, as mentioned in the introduction. A very small amount of sawn timber has been taken out of the forests from time to time, but the bulk of it has stood, till to-day, untouched. Although there are several valuable woods among the mountain trees, notably those of *Dipterocarpus*, *Palaquium* and *Mesua*, natural obstacles have made the forests hitherto commercially worthless and they have been held as State Forests for the sake of their potential value and as a cover and a source of water supply. At present the only extensive agricultural operations are the planting of tea, cardomom and coffee. Some small patches of paddy cultivation are also present in relatively flat country suitable for the purpose.

6. The precipitous slopes are liable to landslips, which occasionally occur during the heavy rains of June to September, and the area they occupy will remain unsuitable and bare for many years.

SECTION 3. *Geology—rock and soil*

7. The underlying rock consists principally of granitic gneisses interspersed by bands of horn blende schist with or without garnet, occasional dolerite dykes and rare patches of basic charnokite and reefs of quartzite. Huge boulders and sheet rock of granitic gneiss are abundant on the ground surface and these cover extensive areas on the slopes of hills and form the beds of the leaping streams or crest the hill tops lending to them often fantastic or weird shapes, and causing them to be known by distinctive names, the most conspicuous among them being "Koonagallu" and "Kudaregallu" in Kemphole forest and "Kanadikallu" in Bisale forest. The presence of granite rock too near the surface is almost entirely responsible for the absence of tree growth on most hill tops and slopes and the consequent rendering of extensive areas ineffective.

8. The soil is generally shallow, consisting of loam of poor quality capping the sheet rock and boulders, but enriched, inspite of its usual shallowness, by the humus of the evergreen forest which, as usual, has created its own soil fertility, and this accounts partly for the fact that once the forest cover is removed the soil deteriorates so rapidly that the reconstruction of the evergreen cover is a very slow and laborious process.

9. The underlying rock crops out frequently at the ground surface. It is superimposed by loam which is generally red on the leeward side of the ghat crest on the plateau, but usually grey on the wind swept westward steep sloping country in which are found pockets of yellow clay or nearly pure white clay sometimes to a depth of 8 feet. On hill tops and ridges pebbly sand-stone which crumbles easily when smashed and generally grey-white in colour is common, and this, probably, gives rise by weathering to the finer grey loam found in the valleys below. With the exception of the pockets of clay mentioned above, the soils are generally shallow, sometimes filled with rock fragments. The humus content is generally high, but the intensity of the surface wash prevents its accumulation except on the floor of the valleys where the soil slope is gentle.

10. The conspicuous difference between the condition of the soil here and in the Shimoga district ghat zone is the absence of the vesicular and porous ferrugieous laterite rock and the deposit of lateritic earth. Although on passing the crest of the ghat into the tableland red loam is commonly found, there is no deposit of typical laterite or any underlying laterite rock within the limits of the forest area.

SECTION 4. *Climatology*

11. *General.*—The climate of the Hassan ghats is like that of the rest of the Western Ghat region within Mysore. The temperatures do not record any extremes, i.e., are relatively constant and low as compared with those of the low-lands of South Kanara but never so low as to make frost possible, and the rainfall is very abundant in the rainy season during the south-west monsoon. The Western Ghat region is, therefore, a *tropical, montane evergreen region,* lying above the hot lowlands fringing the coast of the Arabian Sea, and not attaining to a sufficient altitude for temperate and alpine influences to come into play. The dominant vegetation is, in accordance with the climate, the evergreen broad-leaved rain forest, which is here of a type strongly tropical in its floristic make up and in its vegetative characteristics.

12. The following data on the climatology of the rain forest region are based on the records kept by the Meteorologist to the Government of Mysore at Marnalli and Hanabal and by the Manager of the Kadamane Estate. The observations made at Marnalli and Hanabal are published currently in the reports of the Meteorological Department of Mysore. Using these data and that of the Kadamane Estate and other estates as a basis, the writer has endeavoured to determine to what extent the climatic conditions of the region as a whole have contributed to the typical tree associations and how far the physical and edaphic factors have been responsible for the variations in the distribution of the tree species within the area.

13. *Rainfall.*—The rainfall readings have been made from the standard rain-gauge of the Mysore Meteorological Department from day to day as the fall required. The following table shows the total monthly rainfall in inches for the localities :—

Rainfall in inches

Place	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Hanabal (1941) ..	..	0·12	..	1·47	4·61	39·11	59·89	37·24	9·19	6·29	1·52	2·87	162·31
Marnalli toll-gate (1941)	..	..	..	0·04	7·02	62·85	90·55	75·00	9·52	3·20	..	1·35	249·53

Kadamane—Rainfall in inches

	1939	1940	1941	1942	1943	Average
January	..	0·03	0·11	..	0·90	0·20
February	..	..	0·06	..	..	0·01
March	0·64	..	..	..	0·03	0·13
April	2·90	5·51	1·05	2·39	1·46	2·66
May	1·50	4·41	3·88	2·31	15·94	5·60
June	46·38	62·54	59·60	56·16	57·59	56·45
July	105·20	82·42	78·34	118·75	106·59	98·26
August	73·97	74·44	79·09	52·42	..	55·98
September	20·47	9·24	16·95	20·20	..	13·37
October	11·28	10·61	3·29	5·03	..	6·04
November	3·82	5·54	1·25	0·94	..	2·31
December	..	0·52	2·59	0·82	..	0·79
TOTAL	266·16	255·26	246·21	259·02	182·51	241·80

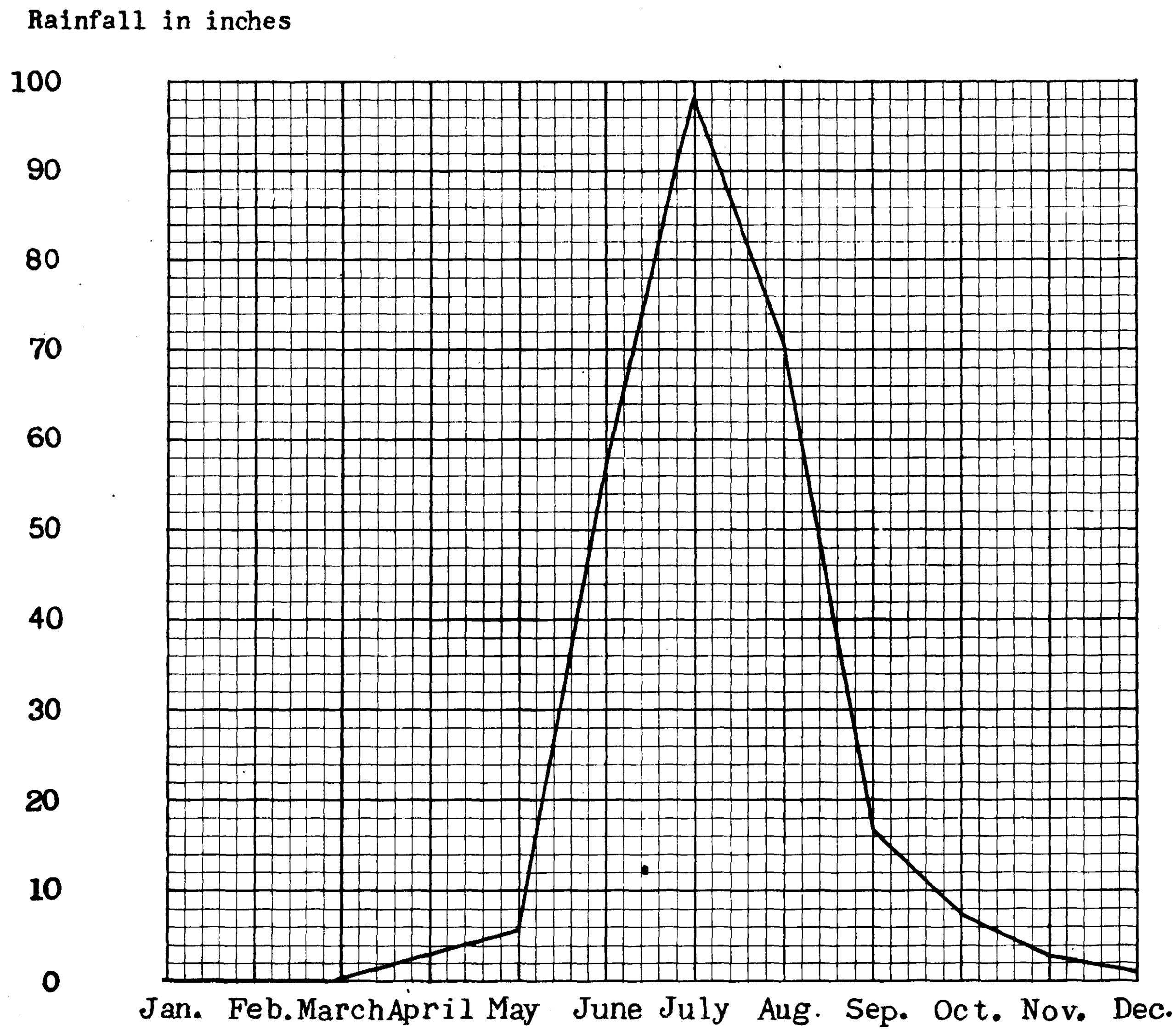

Rainfall in inches
100
90
80
70
60
50
40
30
20
10
0
Jan.
Feb.
March
April
May
June
July
Aug.
Sep.
Oct.
Nov.
Dec.

Figure 1.

14. The data for the stations show very abundant rainfall at one season only, but the fall at Hanåbal is not so high as at Marnalli toll-gate or Kadamane, because the former is situated fairly inland on the plateaux and not at the crest of the ghat where the forests lie. The forest area enjoys, probably, even heavier rainfall than is indicated by the record at Marnalli toll-gate or Kadamane; and this assumption is justified by the rainfall recorded at other stations situated at the crest of the ghat in Shimoga and Kadur Districts. There is very heavy fall between June and August, the peak month being July and practically no rainfall in the summer months between January and April which are consequently very dry, while between September and December there is some, though relatively light, fall.

15. The drought of summer is fairly severe and serious enough to cause most of the hygrophylous vegetation-algæ, liverworts and many ferns—to shrivel and disappear, and to make many trees of the evergreen forest to shed a good portion of their leaves, some even their entire leaf cover. Yet, the shedding is not so heavy as to change the essentially evergreen look of the forest, or embrown the leaf canopy as a whole, like what we find in the mixed-deciduous (moist-deciduous) zone of forests. This is because, inspite of the great variation of the rainfall from month to month and season to season, the soil retains adequate quantity of moisture throughout the year to enable the plants to carry on photosynthetic activity more or less uninterruptedly. In other words the soil acts as the chief regulator of the water household of nature. There is, therefore, no wholesale leaf shedding even in the dry, summer months preceding the monsoon.

16. The south-west monsoon commences generally in the latter half of June, but it is preceeded by the pre-monsoon thunder-showers in April and May. The monsoon increases in in intensity and reaches its peak in July, which is the rainiest month. Its fury abates by the end of August and September is a month of fairly low rainfall. The north-east monsoon is weak and brings little rainfall. (see rainfall graph; figure 1).

17. *Air temperature.*—The record of air temperature for Hassan consist of daily readings of the maximum and minimum and of the current temperatures at 8 hours.

18. The following tables show the temperatures at that place.

Monthly mean 8 hours Temperature in 1941*

January	66·0°
February	67·6°
March	72·2°
April	75·9°
May	75·2°
June	71·5°
July	70·5°
August	70·7°
September	70·6°
October	72·2°
November	70·9°
December	66·2°

*Monthly mean minimum/maximum dry temperature and its variation from the average of 45 years**

	Minimum		Maximum	
	°F	°F	°F	°F
January ..	59·2	+3·1	81·3	−0·5
February ..	61·6	+3·0	85·2	−0·9
March	66·4	+3·9	91·5	+0·9
April	69·5	+2·9	93·3	+1·9
May	69·6	+2·6	89·6	+1·4
June	67·3	+1·5	80·0	+0·2
July	66·3	+1·3	78·6	+1·8
August ..	66·7	+2·2	78·7	+0·6
September ..	66·3	+2·3	80·4	0
October ..	63·2	+1·1	82·4	+1·0
November ..	63·9	+3·2	82·2	+2·3
December ..	58·7	+2·1	80·6	+1·2
YEAR ..	65·1	+2·5	83·7	+0·9

* Meteorology in Mysore, 1941, by C. Seshachar, Esq., M.A., F.R. Met. S., Meteorologist in Mysore.

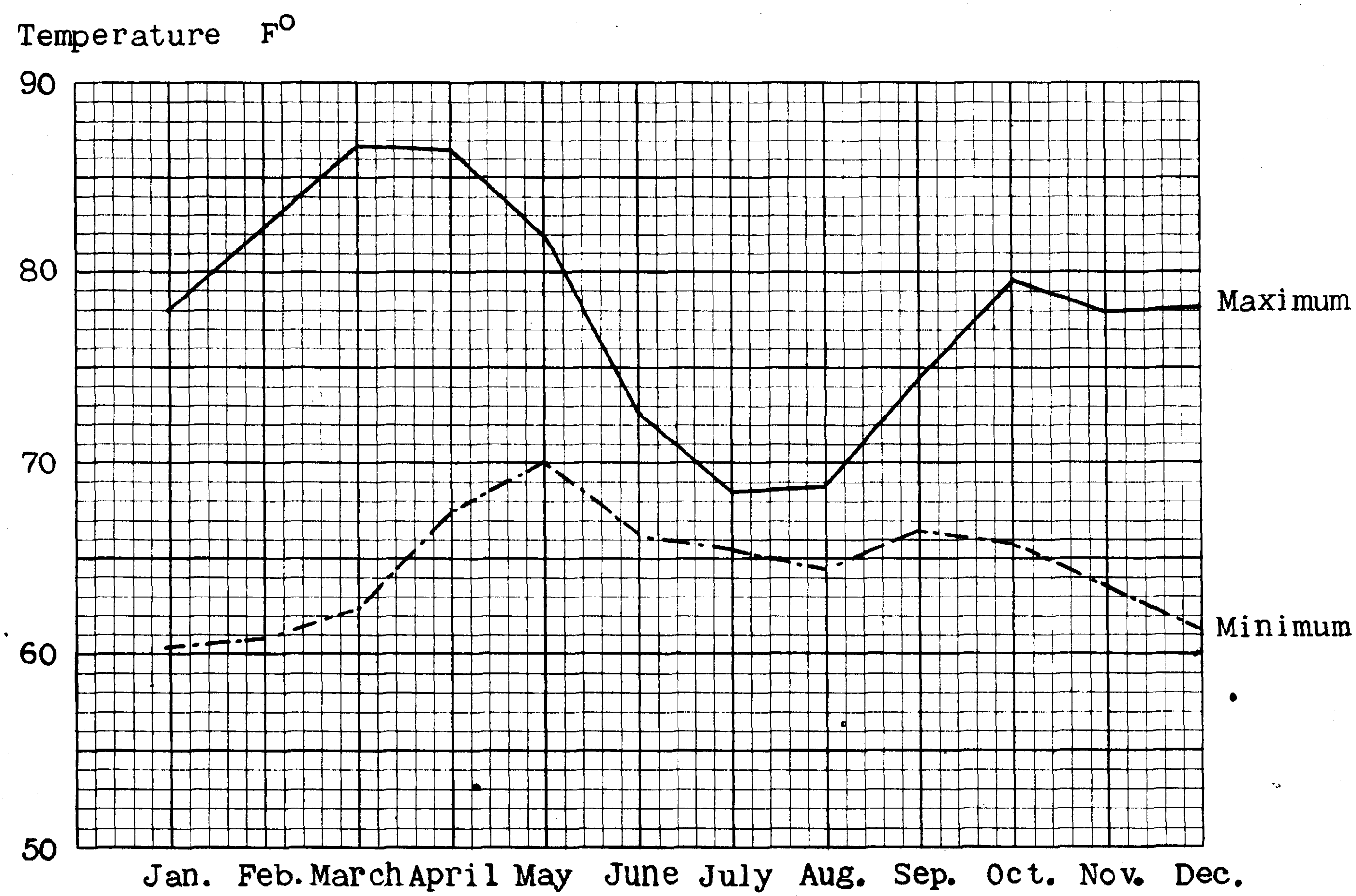
	Monthly mean daily dry temperature in 1941 and its variation from the average of 45 years*		Monthly maximum dry temperature in shade in 1941*		Monthly minimum dry temperature in shade in 1941*	
	Means for 1941	Variation from average	Maximum temperature	Date	Lowest temperature	Date
	°F	°F	°F	°F	°F	°F
January ..	70·3	+ 1·4	83	9th	50	16th
February ..	73·4	+ 1·1	88	19th, 22nd and 29th	51	1st
March ..	78·9	+ 2·4	94	29th and 31st	55	5th
April ..	81·4	+ 2·3	95	14th	63	4th
May ..	79·6	+ 2·0	92	18th	65	4 days
June ..	75·5	+ 2·7	87	10th	65	4 days
July ..	72·5	+ 1·6	78	6th, 7th, 10th and 13th	65	5 days
August ..	72·7	+ 1·4	79	7th and 30th	60	11th
September ..	73·3	+ 1·1	86	26th	61	20th
October ..	73·8	+ 1·1	86	6th	60	19th, 20th and 29th
November ..	73·1	+ 2·8	81	8th, 28th and 30th	57	21st
December ..	69·7	+ 1·7	83	12th	54	29th, 30th and 31st
YEAR ..	74·5	+ 1·8	95	April 14th	50	January 16th

* Meteorology in Mysore, 1941, by C. Seshachar, Esq., M.A., M.R. Met. S., Meteorologist in Mysore.

19. A fairly correct record of temperature has been maintained at Kadamane (see temperature graph, Figure 2) which lies adjoining the forest area. The following table gives the details :—

Kadamane

	1939		1940		1941		1942		1943		Average	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January ..	78	62	78	60	78	59	78	61	78	60	78·00	60·4
February ..	84	62	80	61	82	61	83	62	83	58	82·4	60·8
March ..	85	64	83	60	89	66	86	64	90	58	86·6	62·4
April ..	84	66	84	67	90	71	86	71	88	62	86·4	67·4
May ..	81	71	80	68	82	70	84	71	82	70	81·8	70·0
June ..	72	64	74	68	73	68	70	66	74	65	72·6	66·2
July ..	66	64	68	66	72	65	68	66	68	66	68·4	65·4
August ..	68	66	69	63	70	64	68	65	..	..	68·75	64·5
September ..	74	72	78	64	74	64	72	66	..	..	74·5	66·5
October ..	76	68	80	64	82	65	80	66	..	..	79·5	65·75
November ..	78	64	76	62	80	66	78	62	..	..	78·0	63·5
December ..	79	60	78	60	78	62	78	63	..	..	78·2	61·25



Temperature F°
90
80
70
60
50
Maximum
Minimum
Jan.
Feb.
March
April
May
June
July
Aug.
Sep.
Oct.
Nov.
Dec.

Figure 2.

Cursory observations and readings taken in the forest show that radiation takes place most actively during the early hours of the night, while the minimum temperature is reached just before day break, and this makes it necessary to derive the lowest temperatures due to radiation by subtracting 8° or thereabouts from the temperatures shown by the records of monthly extremes. Within the forest area the temperature falls very considerably by night, the cold resembling what one would experience on a chilly November night out in the plains of Northern India.

20. *Humidity and fog.*—High humidity prevails generally at all times, especially under evergreen cover, and even in the rainless season from January to April there is some precipitation of moisture in the early mornings and just before day break. This moisture drips from the crowns of trees like a continuous though weak shower which is yet so heavy as to resemble a miniature rainfall of the mixed-deciduous zone. In the rainy season the monsoon winds from the Arabian Sea, which come saturated with water vapour, cool on ascending the steep, or nearly vertical, hill slopes and call forth almost incessant precipitations. In this season water trickles down the leaf surface of trees almost continuously, and the humidity of the atmosphere remains throughout the day and night at saturation point. In summer the heat causes sometimes a warm fog to ascend by day from the numerous perennial sources up into the leaf canopy whose top stands in some places over a hundred and fifty feet high, and the water which thus saturates the atmosphere is eliminated during the cool hours of the early morning by precipitation as described above.

21. *Sunshine and Cloudiness.*—No indication of the relative amounts of sunshine and cloudiness is given by the figures exhibiting the number of rainy days in Hassan, as this place is too far away from the forest. Once the monsoon rains start in June, the percentage of cloud reaches 100 per cent, and this remains so throughout July and August. In other words, during these months sunshine is practically absent and the sky remains clouded throughout the day and the night ; a dense mist which blurs human vision even at a dozen feet envelopes the whole atmosphere within and around the forests and hill peaks every few minutes, and this is followed almost at once by heavy rainfall which lifts this veil of mist and brings temporary clearness. This is followed again by the misty cloud. Late in August or early in September the weather clears and intermittent sunshine appears.

22. *Wind.*—The wind is prevailingly from the west and south-west, and commonly reaches its highest force at night and in the rainy season, from June to August. Its influence on the vegetation is greatest on the peaks and ridges, and the fact that the lowest humidities accompany high wind probably makes its dessicating influence considerable. The monthly mean wind velocities in miles per day and the mean wind direction at 8 hours at Hassan is shown in the following tables. The velocities are much greater at the head of the ghat.

	*Monthly mean wind velocity in miles 1941**	*Monthly mean daily wind direction in 1941**
	Means for 1941	Means for 1941
January ..	64	38° S.E.
February ..	67	21° S.E.
March ..	93	54° S.W.
April ..	127	72° S.W.
May ..	161	87° S.W.
June ..	240	77° S.W.
July ..	246	74° S.W.
August ..	232	W.
September ..	165	W.
October ..	107	11° N.E.
November ..	79	82° S.E.
December ..	76	81° N.E.

* Meteorology in Mysore 1941 by C. Seshachar, Esq., M.A., M.R. Met., S., Meteorologist in Mysore.

SECTION 5. *The flora of the evergreen forest*

23. Throughout the history of the botanical exploration of India, the flora of the Western Ghats of Mysore has received little attention from the few systematic botanists who visited the State. More recently owing to the

exertions of the Forest Botanist at the Forest Research Instituate, Dehra Dun, the tree stand in portions of the Western Ghat forests adjoining Mysore territory received some attention, and knowledge of the systematic composition of the tree growth there has greatly increased. It is unfortunate that the time has not yet come in Mysore when the need for a complete flora of the ghat forests of our State is felt. The unfolding of the economic resources of our forests is so closely linked up with a complete knowledge of their systematic composition that the sooner this knowledge is gathered the better. At the present time these mountain forests have to be considered as "floristically incompletely known" even in their very accessible portions; and in the less accessible places few human beings have as yet set their foot except probably stray forestmen, such as the writer, who have to visit them for forest utilization or allied work which gives them little respite for a pure botanical survey.

24. There is no comprehensive systematic work for the region under consideration. Among the systematic works useful for consultation are :—

(1) *Flora of British India* by Sir Joseph Dalton Hooker.

(2) *Flora of Bombay* by Theodore Cooke.

(3) *Flora of Madras* by J. S. Gamble.

No manual exists for Pteridophytes except the work of Beddome—"Ferns of British India". I have therefore depended for my knowledge of the flora on the above mentioned works and on the determinations of my own collections.

I have not been concerned with a complete listing of the flora, but have endeavoured to secure determinations of all species which go to make up the economically useful portion of the crop or govern the characteristic features of the vegetation.

25. *List of characteristic plants.*

Dicotyledons—*1. Angiospermæ*

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
RANUNCULACEÆ		
Clematis gouriana	Gori-bilu,	..
Clematis wightiana	sali-maddina-hambu	
Naravelia zeylanica	..	..
DILLENIACEÆ		
Dillenia pentagyna	Kanagalu	Kanagalu
MAGNOLIACEÆ		
Michelia nilaghirica	kendasampige	..
ANONACEÆ		
Unona pannosa (Dal.)	..	kadu bende
Unona discolor (valh.)	..	..
Artabotrys zeylanicus	kadu-kittale bilu	..
MENISPERMACEÆ		
Cocculus macrocarpus (wright arn.)	..	..
Cyclea peltata	..	..
Tinospora cordifolia	..	..
BIXACEÆ		
Flacourtia montana	kulla-jepalu	sampe
Hydnocarpus wighttiana (Indian Chalmoogra)	yethina-tara-dina-kayi, kalduvala, chengavara	surati
HYPERICACEÆ		
Hypericum mysorense (Heyne)	..	..
GUTTIFERÆ		
Garcinia xanthochymus (Hook)	..	Jeerakanahuli
Garcinia cambogia (Desrouss)	mantahuli	kadagolu-maruga
Garcinia indica	muruglu	guaragi
Garcinia morella	makkala-tayi-mara	arisina-guaragi
Calophyllum elatum, (Bedd.)	bobbi	surahonne
Calophyllum wightianum, (Wall.)	bobbi	holehonne
Mesua ferrea, (Linn.)	balagi	nagasampige
TERNSTRŒMIACEÆ		
Gordonia obtusa	naganamara	mallanga
DIPTEROCARPACEÆ		
Dipterocarpus indicus	halamaddi	dhuma
Hopea parviflora, (Bedd.)	kiralbhogi, bogi	kiralbhogi bogi
Hopea wightiana (Wall.)	karehagalu bilehagalu	haiga, malehaiga
Vateria indica	haiga	sal-dhupa
MALVACEÆ		
Bombax malabaricum, (D. C.)	burulu	buruga
Hibiscus furcatus	gowri-bilu	hulugobri-beelu
Abutilon polyandrum	..	..
STERCULIACEÆ		
Sterculia guttata, (Roxb.)	konan-tholdina-mara	huli-thardina-mara
Helicteres isora, (Linn)	kade-hurukla	kowri, yedamuri, balamuri
Pterospermum rubiginosum (Heyne.)	hunjanmara	..
TILIACEÆ		
Grewia umbellifera	..	..
Grewia tiliæfolia	tadasalu	..
Elæocarpus oblongus, (Gærtn.)	nai-tupru	..
Elæocarpus tuberculatus, (Roxb.)	hanal-tare	sataga

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
TILIACEÆ—(contd.)		
Elæocarpus munroii (?) (Mast.)	tupru	..
MALPIGHIACEÆ		
Hiptage madablota, (Gærtn.)	..	..
RUTACEÆ		
Evodia roxburghiana, (Benth.)	magali, devadari, kamblimara	mangappe
Clausena indica, (Oliver)	..	..
Clausena willdenowii	..	..
Zanthoxylum rhetsa	jumma	jummanamara
Luvunga eleutherandra, (Dalz.)	..	..
Atalantia monophylla (Correa)	..	..
Atalantia missionis	..	..
Paramignya monophylla, (Wight.)	..	..
Toddalia aculeata	Guda-menasina-bilu	..
SIMARUBACEÆ		
Ailanthus malabarica, (D. C.)	halamaddi	maddi-dhupa
BURSERACEÆ		
Canarium strictum, (Roxb.)	guggala	kayi-dhupa
Garuga pinnata, (Roxb.)	godda	godda
MELIACEÆ		
Heynea trijuga, (Roxb.)	kaggale	..
Dysoxylum malabaricum (Bedd.)	devagare, devagarige	devadari
Aglaia odorata (Blume)	kengavara	kempunola
Lansium anamalayanum, (Bedd.)	..	chigatamari
Cedrela toona (Roxb.) (Red-Cedar)	nogavara	gandhagarige
CHAILLETIACEÆ		
Chailletia gelonioides	..	kadutengu
CELASTRINEÆ		
Celastrus paniculata, (Willd.)	..	gangumœ
Euonymus indicus, (Heyne.)	benne-muthaga	kan-kithulli kuranthi
Lophopetalum wightianum, (Arn.)	hebbale	bite-hebbalasu
RHAMNACEÆ		
Zizyphus xylopyrus, (Willd.)	..	..
Zizyphus rugosa, (Lamk.)	..	bemmaralu
AMPELIDEÆ		
Vitis lanceolaria	..	norlebilu
Vitis tomentosa	..	..
Leea sambucina	..	mitli
Leea macrophylla	..	..
SAPINDACEÆ		
Allophylus cobbe	..	..

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
SAPINDACEÆ—(contd.)		
Schleichera trijuga, (Willd.)	sagade, karisagade	kendala, keli
Nephelium longana, (Camb.)	kanu-kendala	sannele-kendala
SABIACEÆ		
Meliosma wightii	..	..
ANACARDIACEÆ		
Mangifera indica	mavu	mavu
Holigarna arnottiana, (Hook)	kutageri	sannele-holegara
Holigarna grahamii, (Hook)	tatagiri	doddele-holegara
Holigarna sp.	kadu-geru	badacharlu
Nothopegia colebrookiana (Blume)	..	..
LEGUMINOSÆ		
Mucuna pruriens	..	nasgunni
Erythrina stricta	..	keechakanamara
Spatholobus roxburghii	..	ujinabilu
Butea frondosa	muthaga	muthaga
Butea superba	muthugada-hambu	muthugada-bilu
Dalbergia latifolia, (Roxb.)	bite, biti	bite, biti
Pterocarpus marsupium, (Roxb.)	rakta-honne	honne
Derris sp. (?)	..	..
Pongamia glabra, (Vent.)	honge-mara	honge-mara
Cæsalpinia sepiaria, (Roxb.)	badabakka	..
Acrocarpus fraxinifolius, (Wight.)	havalige	havalige
Kingiodendron pinnatum, (Bor.)	yennemara	..
Saraca indica, (Linn.)	..	ashoka
Cassia fistula, (Linn.)	kakke	kakke
Humboldtia brunonis, (Wall.)	yesale	asage, kan-asoka
Bauhinia phœnicea, (Heyne)	basavanapdada-hambu	basavanapadada-bilu
Bauhinia malabarica, (Roxb.)	basavanapada	basavanapada
Entada scandens, (Benth)	anemettina-hambu	ganape-bilu
Xylia xylocarpa	..	jambe
Mimosa pudica	..	..
Acacia cæsia, (Willd.)	kaduseege	kadusigemullu
Albizzia stipulata, (Boivin.)	..	chattumbe
Pithecolobium bigeminum, (Martins.)	..	korachatte
CRASSULACEÆ		
Bryophyllum calycinum	..	*yele-chigurugida*
RHIZOPHORACEÆ		
Carallia lucida (Roxb.)	tora-halasu	nai-halasu
COMBRETACEÆ		
Terminalia belerica	tare-mara	tare-mara
Terminalia chebula	..	alale
Terminalia tomentosa	kare-mathi	karemathi
Terminalia arjuna	bilemathi	bilemathi
Terminalia paniculata	huli-sagade	hunalu

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
COMBRETACEÆ—(contd.)		
Calycopteris floribunda	..	kumsanballi
Combretum ovalifolium	..	..
MYRTACEÆ		
Eugenia munronii, (Wight)	..	..
Eugenia jambolana, (Lam.)	nerlu	nerlu
Eugenia hemispherica, (Wight)	mattanerlu	..
Eugenia gardneri, (Thw.)	..	male-nerlu
Eugenia zeylanica	..	kunnerlu
Eugenia corymbosa	..	..
Eugenia læta	chappalu	kadu-pannerle
Eugenia heyneana	..	meenangi
Careya arborea (Roxb.)	kowlu	kowlu
MELASTOMACEÆ		
Melastoma malabthricum, (Linn.)	nekkarike	dodda-nakkarike
Osbeckia truncata .	..	sanna-nakkarike
Memecylon edule, (Roxb.)	udatale-kaddi	hulichappu, adachari
Memecylon amplexicaule (Roxb.)	..	volle-kodi
Memecylon amabile	..	..
LYTHRACEÆ		
Lagerstrœmia lanceolata	nandi	nandi
Lagerstrœmia flos-reginæ	..	hole-dasavana
SAMYDACEÆ		
Casearia rubescens	..	..
DATISCACEÆ		
Tetrameles nudiflora	..	..
ARALIACEÆ		
Heptapleurum wallichianum (C. B. Clarke)	..	varekethanaballi
Heptapleurum sp.	anagalubilu	changaranaballi
CORNACEÆ		
Mastixia arborea	Vadare, akka-tangiramara	gulle
RUBIACEÆ		
Sarcocephalus missionis, (Haviland.)	..	..
Hymenodictyon excelsum (Wall.)	..	..
Wendlandia exserta (D. C.)	kadu-bodalu, talige	kan-uragi
Wendlandia notoniana (Wall.)	kadu-bodalu, talige	kan-suragi
Mussænda frondosa (Linn.)	..	..
Webera corymbosa (Schreb.)	..	..
Gardenia latifolia	..	mara-bikke
Randia uliginosa	banagare-kayi	banagare-kayi
Randia dumetorum	kare	kare
Plectronia didyma	abbalu	bilochi kan-bilachi
Pavetta hispidula	..	..
Ixora parviflora	goravi	goravi
Ixora nigricans	kadu-kapigida	yelagara
Psychotria truncata	hampalu	vattamadike
Psychotria thawaitesii	hampalu	vattamadike
Rubia cordifolia	kai-kuyyana-bilu	manjatte-bilu

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
MYRSINACEÆ		•
Embeliaribes	..	vayuvilanga
SAPOTACEÆ		
Chrysophyllum roxburghii	ale	alehale
Palaquium ellipticum	halganne	hadasale
Mimusops elengi	bakula	ranja
Bassia malabarica	kadu-ippe	ippe
EBENACEÆ		
Diospyros paniculata	..	karimarlu
Diospyros microphylla	..	sannele-karimarlu
Diospyros montana	..	..
Diospyros embryopteris	..	hole-tumre
Diospyros ebenum	bale	bale
STYRACEÆ		
Symplocos spicata (Roxb.)	turublu	chunga
OLEACEÆ		
Olea glandulifera	..	..
Olea dioica, (Roxb.)	kal-sandle	madle
Ligustrum neilgherrense	gachalu	chandraka, chandalaka
Linociera intermedia	bangara-sadle	botha-madle
Jasminium rottlerianum	kadu-mallige	kadu-mallige
Jasminium arboresecns	kadu-mallige	kadu-mallige
APOCYNACEÆ		
Carissa suavissima	kavali	karji
Alstonia scholaris	jantavala, kodiyala	madhale
Tabernæmontana heyneana	..	maddarasa
Ichnocarpus frutescens	kari-hambu	..
ASCLEPIADACEÆ		
Hoya wightii	..	peepiballi
LOGANIACEÆ		
Strychnos nux-vomica (Linn.)	kasarka	kasaraka
Strychnos colubrina (Linn.)	..	..
BORAGINACEÆ		
Ehretia lævis	kapura	..
CONVOLVULACEÆ		
Lettsomia elliptica (Wight.)	maribilu	..
Ipomoea campanulata	..	..
BIGNONIACEÆ		
Stereospermum chelonoides	masivara	padri
Oroxylum indicum	..	anangi
ACANTHACEÆ		
Thunbergia mysorensis	..	..
Strobilanthes barbatus (Nees.)	hegguruklu	guragi
Strobilanthes callosus (Nees.)	guraklu	guragi
Strobilanthes perfoliatus	..	guragi
VERBENACEÆ		
Vitex altissima	halabindige	naviladi
Vitex negundo (Linn.)	nakki, rakke-gida	nakki

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
VERBENACEÆ—(contd.)		
Vitex leucoxylon (Linn.)	hole-lakki	bile-lakki
Clerodendron serratum	..	taggi
Clerodendron infortunatum (Gærtn.)	tagadupranti	tagadata
Callicarpa lanata	ibni, tagad-upranti	tagadata
LABIATÆ		
Colebrookia oppositifolia, (Smith.)	ibbani-gida	guragi
Pogostemon plectranthoides (Desf.)	..	..
ARISTOLOCHIACEÆ		
Bragantia wallichi (Rob. Br.)	..	niruvate-beru
PIPERACEÆ		
Piper nigrum	kadu-menasina-balli	kadu-menasina bilu
Piper argyrophyllum	kadu-menasina-balli	kadu-menasina bilu
Peperomia portulacoides	..	..
MYRISTICACEÆ		
Myristica magnifica	natwara	ramanadike
Myristica malabarica	natwara	rampathre
Myristica laurifolia	natwara	ramagotu
Myristica attenuata	natwara	sannale-ramagotu
LURACEÆ		
Litsœa wightiana (Hook.)	hammadde	sudagenasu
Litsœa glabrata	kirele-hammadde	sannale-sudagenasu
Litsœa stocksii (Hook.)	..	..
Litsœa zeylanica	nayi-yelaga	..
Actinodaphne hookeri	yelele-hammadde	galavara
Actinodaphne hirsuta	yelele-hammadde	galavara
Cinnamomum zeylanicum	yelaga	dalchinni
Cinnamomum macrocarpum	yelaga	kankutla
Machilus macrantha (Nees.)	kulmavu	gulmavu
THYMELEACEÆ		
Lasiosiphon eriocephalus	..	mukkadaka
ELÆAGNACEÆ		
Elœagnus latifolia (Linn.)	hulugaraballi	belli-hambu
LORANTHACEÆ		
Loranthus wallichianus	bandare	bandarike
Loranthus obtusatus	bandare	bandarike
Loranthus lageniferus	bandare	batlu-banda-mike
Loranthus loniceroides	bandare	bandanike
Loranthus capitellatus	bandare	bandanike
Viscum angulatum	bandare	bandanike
EUPHROBIACEÆ		
Bischofia javanica (Blume.)	gobar-nerlu	gobar-nerlu
Bridelia retusa	nelagoje, gote	bilkumbe
Bridelia hamiltoniana	nelagoje, gote	bilkumbe
Aporosa lindleyana	..	salle
Breynea patens	okkane	kunkanaka
Glochidion lanceolarium	hanchatte	salle
Glochidion tomentosum	hanchatte	nirusalle

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
Ostodes zeylanica	bale	bale
Sapium insigne (Benth.)	..	ganganamara
Adenochlœna indica	..	..
Mallotus philippinensis (Muell. Arg.)	hullatti	kapila-rangu
Mallotus sp.	hullatti	kapila-rangu
Macaranga roxburghii	upranti	batlu-chandalka
Trewia nudiflora	hole-harivana, niruvana	..
URTICACEÆ		
Celtis australis	..	..
Trema orientalis	gorakallu	gorakallu
Ficus gibbosa	goddu-mitli	..
Ficus retusa	..	..
Ficus arnottiana	..	..
Ficus nervosa	neer-atti	kan-atti
Ficus infectoria	kari-basari	kari-basari
Ficus hispida	kolla	..
Ficus glomerata	atti	atti
Ficus tsiela	bile-basari	bile-basari
Ficus asperrima	..	male-gargatti
Antiaris toxicaria	gadda-hasave	ajjanpatte
Artocarpus hirsuta	hasenmara	hebbalasu
Artocarpus intergrifolia	halasu	halasu
Artocarpus lakoocha	vate, vante-huli	vate
Laportea crenulata	nugga	male-maruga
Streblus asper (Lour.)	vate-buruklu	matli
SALICACEÆ		
Salix tetrasperma	niranji	niranji
Salix ichnostachya	..	..

Monocotyledons

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
LILIACEÆ		
Dracœna spicata	..	..
Smilax aspera	..	..
Asparagus racemosus	huli-rayana-kudi	Shatavari, majjigehambu
Gloriosa superba	..	..
ORCHIDACEÆ		
Oberonia recurva	..	..
Oberonia lindleyana	..	..
Microstylis rheedii	..	..
Dendrobium herbaceum	..	..
Eulophia nuda	..	..
Cymbidium bicolor	..	..
Rhyncostylis retusa	..	..
Saccolabium wightianum	..	..
Vanda roxburghii	..	..
SCITAMINEÆ		
Globba bulbifera	..	..
Curcuma aromatica	..	..
Alpinia galanga	..	..
Musa superba	kadu-bale	kadu-bale
AMARYLLIDEÆ		
Curculigo orchoides	..	nela-tengu
Crinum ensifolium	..	..
DIOSCOREACEÆ		
Dioscorea pentaphylla	..	..
Dioscorea oppositifolia	..	..
PALMÆ		
Pinanga dicksonii	geradalu	janjarige
Caryota urens	bagani	bagani
Phœnix humilis	kirichalu	kirichalu
Arenga wightii	nepalu	dadasalu

Flowering plants	Local name	Name of Shimoga and Kadur Ghats
PALMÆ—(contd.)		
Calamus pseudotenuis	halubetta	halubetta
Calamus thwaitesi	kaman-betta	handi-betta
Calamus sp.	simbe-betha	sanna-betha
Calamus rheedei	..	..
Calamus sp.	nagabetta	(not present)
Caryota urens	bagani	bagani
PANDANACEÆ		
Pandanus furcatus	..	..
Pandanus canaranus	..	..
Pandanus tectorius	..	kyadige
AROIDÆ		
Amorphophallus campanulatus	..	..
Pothos scandens	..	..
GRAMINEÆ		
Bambusa arundinacea	..	(not found)
Ochlandra talboti	..	..
Ochlandra rheedii	..	..
GYMNOSPERMÆ		
GNETACEÆ		
Gnetum scandens	kambli-bilu	kule-bilu

SECTION 6.—*The vegetation of the evergreen forest.*

26. *General.*—The peaks and eroded slopes of the Hassan Ghats, owing to the presence of cliffs and rock out-crops often of considerable size, have very meagre forest covering or are entirely bare, inspite of the lack of any disturbance by man. The colour tone of the landscape here is a dull grey whose continuity is occasionally broken by veins of dark-green shade where forest growth intervenes.

27. The precipitous tops have frequently sheet-rock which excludes tree growth and even grass from the soil, and elsewhere, where the rock is very near the surface, grass is abundant amidst which stand occasional shurbs of *Wendlandia notoniana* which put forth their scented racemes of white blossoms early in the dry season, and the Bracken Fern (*Pteris aquilina*) while the surface of the grass itself is occasionaly littered with the yellow, starlike flowers of *Curculigo orchoides.* The valleys and slopes (Sholas) are the home of evergreen forest of a magnificient type in whose interior there is not much evidence of colours other than green. This condition, along with the general paucity of showy birds and insects gives the forest interior an air of gloom to which its frequent fogginess only adds. The varying tinges of barks of a few trees sometimes serve to relieve the monotony of the tint ; among such trees *Calophyllum elatum* and *C. wightianum* are the commonest.

28. When, however, the evergreen forest canopy is seen from an opposite vantage point in summer, many differences between it and the forest interior strike the eye. The upper surface forms a richly varied mosaic in which every shade of green and often variegated colours are noticeable, the most frequent being the dark-green. By the mere tint of the foliage and the shape of the crowns an experienced forestman can recognize some of the valuable trees of the forest. Among trees so recognizable are :—

Schleichera trijuga with its bright copper coloured foliage, *Canarium strictum* with its long shoots of dark copper colour and tall round-headed crowns, *Dichopsis ellipticum* with its tall, round-headed crowns with light-coloured young foliage and *Dipterocarpus indicus* with its towering canopy which stands for above the rest of the forest.

29. In a side view such as what we find along forest clearings, the evergreen forest differs markedly from other forest types. Especially along water courses, the stems, overladen with lianes and epiphytes, are often scantily visible ; and the great diversity in the size of tree trunks, the irregular tangle of lianes and the variety of foliage crowns impress the eye, lending to the forest growth its characteristic look of maximum disorder.

30. Several gigantic trees tower over the general level of the forest, and the stature of the trees is surprisingly varied inspite of the favourableness of rainfall and temperature ; the largest ones attain in sheltered valleys a height of 150 feet and over. But on ridges, particularly those at high altitudes directly facing the western wind, the largest individuals seldom exceed 30 to 50 feet in height. The combined influence of wind and seasonal dessication caused by the shallowness and low water content of the soil contribute to the low stature of the trees on the open ridges but, in general, the phenomenon is probably also due to the high wind increasing the evaporation which makes its dessicating influence on the forest growth considerable. A good number of trees directly exposed to the western wind on the ridges often exhibit nearly fan shaped crowns caused by the more prominent growth of the branches in the leeward direction, and

this indicates clearly the whipping effect of wind on the tree crowns and its destructive influence on the branches on the windward side.

31. The forests of the Hassan Ghats exhibit pronounced tropical characteristics both in their composition and general ecology. There is not a single species of the temperate type, and no gymnosperm except the gigantic climber *Gnetum scandens*. There are generally considerable peculiarities of form. The larger trees, especially species of the genera *Elaeocarpus*, *Alstonia* and *Ficus* and, to a lesser extent, *Myristica*, *Artocarpus*, *Lophopetalum* and some others exhibit conspicuous plank buttresses. The low trees at the top-ends of the sholas, which usually belong to the genera *Eugenia*, *Symplocos*, *Canthium*, *Olea*, etc., have round, compact heads of foliage, while those standing on wind-exposed tops and ridges have dwarf boles capped by irregularly extending, one-sided crowns.

The bark is generally thin and smooth, but characteristic colours and markings on it are by no means uncommon, making the recognition of a number of tree species possible from the ground. Cauliflory is uncommon, but the genera *Ficus*, *Artocarpus* and *Polyalthia* exhibit this character. Other, purely tropical, characters seen are the occasional bunching of the leaves at the ends of branches and the attenuated leaf ends or "drip tips", but the functional value of this structure has probably been over estimated.

32. In narrow, sheltered valleys there is a lofty closed conopy with very tall, clean, cylindrical stems, and as one proceeds into wider valleys and from them to the slopes and finally on to the ridges and hill tops the stems become less and less clean and tall, and the canopy more and more open, until on the hill-tops and peaks tree growth is altogether absent. The general level of the top canopy is, however, more uniform on the ridges than in the ravines. On ridges, especially when we approach the limit of tree growth of a shola, the canopy has sometimes no line of demarcation from the foliage of the under trees and shurbs, and this results in an irregular and more or less solid mass of foliage from the tree tops down nearly to the level of the terrestrial herbaceous plants.

33. The leaf varies within very wide extremes as regards both size and form, but those of the same species become smaller as the upper limit of tree growth at the top ends of the shola are approached. The great majority of the leaves are simple, large in size, and those of the top layers of the canopy are firm, coriaceous and highly cutinised and contain several layers of palisade cells with little mesenchyma; they contrast with the extremely hygrophilous character of the leaves of the ferns and other herbaceous plants of the forest floor.

34. The floor of the forest is covered with a litter of leaves, twigs and limbs of trees the decay of which proceeds very rapidly in the season immediately following the rains, i.e., between September and December, while the rate of decay is slower both in the dry and in the wet seasons, in the former owing to the litter getting too dry and in the latter to the extreme wetness maintained at relatively low temperatures. Whiteants do a small amount of destruction of the dead trees before they fall, but it is the abundant discomycetous and other fungi which hasten the disintegration of the stems and branches. The soil is extremely rich in organic matter but, except in valleys, it is usually shallow and sometimes full of fragments of rock; occasionally rocky boulders cut up its continuity.

35. The terrestrial herbaceous vegetation varies from extreme wealth in the ravines to almost complete absence in places on the ridges and tops, where, in the absence of sheet rock, grass covers the ground along with masses of the Bracken Fern—*Pteris aquilina*—and thickets of the scrambling fern—*Gleichenia dichotoma*. In the ravines caused by the cutting into the steep ground by forest streams, tree-ferns of the genera *Alsophyla* (Photo 1) and *Angiopteris* occasionally figures along with species of *Blechnum*, *Nephrodium*, *Pteris*, *Peperomia* and others. Terrestrial orchids are usually absent, but the most conspicuous members in some of the valleys are the palms, both erect and climbing; among them are *Pinanga dicksonii*, *Arenga wightii*, *caryota urens* and two or more species of *Calamus*. The large leaved *Musa*—Wild Plantain—is also sometimes seen (Photo 2). The abundance of the palms, both erect and climbing, and the musaceous type of large leaved phanerogams taken together with the paucity of ferns, filmy ferns and bryophytes stamps

upon the vegetation its general tropical character.

36. The epiphytic vegetation is fairly abundant, but tank epiphytes of the bromeliaceous type are absent and large, woody forms are seldom, if ever, seen. Orchids, with either waterstoring leaves or storing roots (velamen-covered) are common, but not so frequent as the ferns, which range from hygrophilous forms to small xerophilous ones, including notably one or two of the Hymenophyllaceae. The bulk of the epiphytic vegetation is made up of mosses and lichens which sometimes serve as a water-retaining substratum for the larger forms.

37. Climbers and lianes are not common under the closed canopy but are abundant along the banks of forest streams scouring the bottom of valleys or in places where the upper leaf canopy is relatively open owing to temporary swampiness, or has been broken and remained so for a long time. Along water courses *Entada scandens* is the commonest climber, while in other places *Gnetum scandens* is prominent. In flat, not very rapidly drained, localities cane-brakes of varying density are found, while elsewhere a host of climbing species are present whose systematic identity has been meagrely established.

38. The continuity of the forest formation is broken, though rarely, by occasional land-slips.

39. It is usually difficult to determine the systematic composition of the large trees, as these hide even their foliage from our view. Only felling them might fecilitate our object but, occasionally, even this will not be easy as the crowns are bound together by lianes, and even if they are felled the results may not be decisive as many trees bloom but scarcely and that for a short time in the year, and both flowers and fruits are not generally found at the same time. One can recognize a few families by their characteristic fruits, eg., the Myrtaceæ and Meliaceæ by their berries, the Myristicaceæ by the aril and the Dipterocarpaceæ by their winged fruits, but this does not satisfy either the botanist or the forestman. Sometimes only corollas are found, but these may belong to the large number of climbers. The identification of the climbers is even more difficult, as they spread their foliage over the tops of the highest trees ; cutting them is of no use and any attempt at pulling them down ends, as a rule, in disappointment.

In many cases, therefore, it is the characteristic barks which enable an experienced person to identity the trees and many climbers*. In Myrtaceæ the bark peels off in flakes ; in certain Leguminosæ the bark is greenish ; in some Guttiferæ the bark has characteristic furrows and tinges ; in the genus *Myristica* a blood red exudation rapidly emerges and trickles down the bark on wounding. *Mesua* has the bark peeling off in flakes, and exudes a whitish liquid turning yellow ; the Guttiferæ in general, exude a deep yellow resinous liquid on wounding ; in *Holigarna* a dull white corrosive juice exudes from the chopped bark which turns black on exposure. The conspicuous plank buttresses enable one to recognize Elæocarpus, while the colour of the young foliage may enable one to identify *Schleichera trijuga, Canarium strictum and some others.*

40. It is easier to acquire a knowledge of the systematic position of the underwood as many of these flower and fruit for a longer time in the year. The ferns bear their spores mostly in the months after the monsoon—November to January—when they can be easily identified.

(To be continued)

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* The Evergreen forest, Agumbe Zone, by Krishnaswamy Kadambi, Mysore Forest Journal 1934.

SAMPLING TECHNIQUES

Adaptation of modern statistical methods to the estimation of forest areas, timber volumes, growth and drain

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It is gratifying that the United Nations Scientific Conference on the Conservation and Utilization of Resources should include the subject of sampling techniques in its deliberations. India has played a leading role in the development of these techniques, especially in estimating area and yield of agricultural crops—a fact which received recognition by the appointment of the leading Indian Statistician, Professor P. C. Mahalanobis, F.R.S., to the Chairmanship of the Sub-Commission on Statistical Sampling of the United Nations Statistical Commission. The report of this sub-commission which met in full session in September 1947 has been published. It contains detailed recommendations on use of sampling techniques.

In writing an "experience" paper on sampling techniques as applied to forestry in India, I am at a disadvantage as my experience in this field is limited to little over one year. I can therefore only act as a 'medium' for summarizing the past experience of forest research officers in India, as recorded in published accounts.

One of the main sources of information on the progress of forest research in India is the Proceedings of the Silvicultural Conferences which ordinarily meet once in five years at Dehra Dun. The first Conference met in 1918 and the most recent one in the series was the Seventh Conference which met in 1946.

Sampling for estimation of forest areas.—Estimation of area under forests is no longer a serious problem in India. Although vast in area, India is also very thickly populated and there is little forest land which has not been surveyed and mapped out.

No doubt, sampling techniques could be adopted in the estimation of forest areas. As an example, the writer can cite the Swedish National Forest Survey of 1923–29 of which he has seen only a short account published in English. It is presumed that details of the technique of this sample survey and of improvements in technique in more recent surveys will be presented to the conference by a representative of that country.

Sampling for estimating timber volumes, yield, etc.—This problem has been tackled in India under three main techniques. (1) Sample Plot method for regular even-aged forests ; (2) Linear or 'tree increment' plot method for irregular uneven—aged forests ; and (3) Partial enumeration of standing crop in large forest tracts.

(1) *Sample plot methods.*—The Sample Plot procedure followed in India is based on Schwappach's form factor method. The rule for selection of sample plots is that they "should be selected in crops of all ages, and should be well distributed over the whole range of quality, types and geographical distribution of the species". There is very little scope for random selection. The choice of the exact location of the sample plot is left to the judgement of the local officers and this is perhaps as it should be.

Having laid out a sample plot, the Indian method consisted in selecting not less than 6 (and not more than 12) sample trees for measurement. They were as a rule, selected from trees marked for thinnings, to obviate the need for measuring heights of standing trees. The rule laid down was that "a sample tree of a given diameter should be representative of its diameter class in height, form and crown development".

In actual practice, however, the sample trees selected covered only the full range of diameters.

Mr. Laurie, the Central Silviculturist, said as follows at the Fifth Silvicultural Conference, 1939 (p. 252 of the Proceedings) :—

> "In compiling Yield Tables it is invariably found that irregularity of the data was due to a great extent to imperfect selection of sample trees. There were two main defects generally, namely :—
>
> (1) Sample trees were not sufficiently nearly representative of their crop height and diameters.

(2) Sample trees were usually inadequate for the larger diameter classes.

In India we are very fortunate in having a relatively simple and easy procedure for measuring sample trees. Silviculturists may be thankful that they do not have to do sample plot work as it is done in some countries, such as Finland, where a complete set of sample trees is measured for each canopy class involving 24 to 30 trees in each plot instead of our 6 to 10. If we are to obtain satisfactory results with our small number of sample trees great care must be taken that those trees are really representative of the crop. The new proposals stiffen up the rules for the selection of sample trees a little, and involve the measurement of a number (not less than 12) of standing heights and the drawing of a height/diameter curve in the field. The sample trees are then selected so that their heights fall within 3 per cent of the value given by the curve for the same diameter. A number of silviculturists do this already, but it is desirable that it should be adopted as a standard procedure".

In 1934, Mr. Champion made a test of the precision of the standard Indian Sample Plot Methods and three years later, Mr. Kakazai made a similar study. Both the papers ascribe large differences, wherever they have occured, to the selection of insufficiently representative sample trees.

From the point of view of modern sampling technique an excellent opportunity was missed in these studies to test whether selection of the sample trees *at random* from all the trees in the plot with or without stratification into different diameter groups would have given estimates of volume with sufficient precision for practical purposes. Further, the extent of improvement in precision by increasing the number of sample trees from 6 to say 12, 15 or 20 would also have been worth while. Without some such study it is difficult to suggest an efficient sampling technique for selection of trees for measurement within individual sample plots.

(2) *Linear Sample Plots for irregular crops.*—Based on the Standard Sample Plot procedure we have now volume and yield-tables for a good number of important Indian species of timber. These tables, however, only touch the fringe of the problem of the collection of growth statistics, since only a very small percent of total area is actually under uniform systems. Since the Standard Sample Plot procedure was not applicable to our mixed forests, some Provinces, notably Bengal, the United Provinces and Madras laid out a number of 'linear sample plots' which later came to be known as "Tree Increment" plots.

Bengal was the pioneer in the field. With the object of obtaining facts as to distribution and percentage of species in different types of forest and at the same time to get some idea as to the diameter increment of the individual species, Mr. Shebbeare, Silviculturist, Bengal, started in 1923 to lay-out linear sample plots in the forests of the Buxa and Jalpaiguri divisions.

The method of laying out these lines was described by Mr. Homfray at the Third Silvicultural Conference, 1929 as follows :—

> "Lines were marked on the map *at random* and laid out on the ground afterwards; this prevented any attempt to select the best areas which might be the case if lines were selected on the ground. The width of the line was one chain and the length might have varied from ½ to 2 miles until it reached some convenient boundary. Every tree of 5″ diameter and over at breast height whose centre occured within the lines was numbered by a tin plate. Trees under 5″ diameter were ignored. Diameter measurements were taken every two years for the first four years and thereafter every three years".

In the United Provinces and Madras the linear plots were not laid out at random. At the Forth Silvicultural Conference, 1934, the methods used by these two Provinces were described. In the case of United Provinces, Mr. Mobbs said :—

> "The lines certainly include almost ever possible sub-type. What is not certain, however, and can never be certain, is that the proportion of these sub-types is more or less the same as their proportions in the main types as a whole".

As regards the Madras plots Mr. Laurie, the Provincial Silviculturist said :—

> "It is assumed that the plots have been selected so as to cover the whole range of

quality and geographical distribution to be studied and that the plots are typical of the forests as regards uniformity and density, and that they will give diameter increment data for trees of every crown and canopy class".

For want of a standard procedure not much progress was made in the analysis of the data collected at successive measurements from these linear plots. At the 1939 Silvicultural Conference the subject came up for discussion. Mr. Laurie, the Central Silviculturist said :—

"It is, as pointed out at the last conference by Champion, generally impracticable to run a sufficient length of line to give a proper sample of the forest in which all changes of type, quality and distribution of size classes in the forest are proportionally represented. Depending upon the variation encountered such a sample might have to cover from about 10 to 25 percent. of the area to be reliable, i.e., a similar proportion of the area to that required for a working plan enumeration".

In an appendix to Mr. Laurie's paper a standard procedure for laying out linear sample plots was proposed which laid down that the lines should be first marked at random on a contour map of the area in a direction more or less at right angle to the contour.

The war intervened and hampered further progress in the linear sample plot method.

(3) *Partial enumeration.*—The Sixth Silvicultural Conference was held in 1945 soon after the end of the war when the question of enumeration of forests, both regular and irregular, loomed large for revision of working plans necessitated by heavy war fellings and for post-war development plans. In a paper presented to the Conference, Dr. Griffith, the Central Silviculturist, pointed out the desirability of adopting methods of random sampling in forest enumerations. He said that this was the current practice in America in their timber "cruises" and quoted examples from a recent book "Sampling Methods in Forestry and Range Management" by F. X. Schumacher and R. A. Chapman which went to demonstrate the superiority of random sampling over systematic strip sampling.

Dr. Griffith had in hand some data of complete enumeration comprising an area of 17,000 acres in a Madras forest in which the estimated timber volume was available for every $1\frac{1}{2}$ acre (3 ch. $\times$ 5 ch.) plot of the area. For each species (53 species in all) records were kept by a foot breast height girth classes from 3 feet to 8 feet and over and also the number of poles up to 3 feet in girth. Breast height girth measurements were converted to volumes from local volume tables, poles being recorded separately.

Dr. Griffith tried out various sampling schemes 'on paper' with these data and also on data (not so good) supplied by some other provinces. In a paper read at the Seventh Silvicultural Conference in 1946 he summarized the main results of his investigations. He concluded that

"Systematic sampling in general gives us rather more accurate and more precise estimates than random sampling provided it is carried out with a full appreciation of the probable trends of the fertility gradients of the forest".

Whether this conclusion may turn out to be true or not for the specific data used by Dr. Griffith, his methods of calculating the sampling error of his estimates were open to serious criticism as pointed out by Dr. Finney. To quote the latter :

"Though a systematic sample may be expected usually to give an estimate more precise than would the corresponding stratified random sample, this is not necessarily true. For some types of variation the precision for the systematic might be lower, and no general statistical theory can state that one will always be better".

In the 1942 edition of their book on "Forest Mensuration" Bruce and Schumacher discuss the conflicting advantages of the systematic and random methods of sampling. They say:

"Systematic Sampling is much more commonly used than random sampling in estimating the true characteristics of forest populations on confined areas."

Again, for systematic sampling, they list a number of advantages of circular plots over strips. We have no experience in India of working with circular plots in forest enumerations. Dr. Griffith's study is limited to systematic strip sampling. It is seldom that you will come across a forest where the indivi-

dual strips will be of the same length and area. In the Madras data Dr. Griffith found that the strips varied in area from 20 to 70 acres. This variation in size of the sampling unit can be avoided if *plots* of definite shape (circular or rectangular) and size are used as sampling units instead of strips.

There is another important point, namely, errors of the enumerating party. These errors will be there whether it is a complete enumeration or a partial enumeration, unless the field staff consists of well trained men. Methods have been developed by Professor Mahalanobis for controlling this source of error by his technique of inter-penetrating sub-samples. There is a great need for this type of statistical control in forest sampling.

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ADDENDUM

Since preparing the paper as presented above, I came across two important contributions on the subject of systematic sampling published by Dr. D. J. Finney and by Dr. F. Yates. Dr. Finney's paper is a piece of applied statistical research based on specific data of timber surveys conducted in India and in the U.S.A. It is written in non-technical language as a sequel to the earlier paper published by him in the same journal a year ago.

By obtaining correct values of precision of systematic sampling for the Indian data with the aid of the principle of "end-corrections" put forward by Dr. Yates, Dr. Finney made amendment for Dr. Griffith's earlier errors in handling these data and was also able to make valid comparisons between this precision and that attainable by stratified random samples. He found that systematic sampling gave more precise estimates of volume per acre than stratified random sampling.

Whether a stratified random or systematic

sample was used, the Indian data examined by Dr. Finney clearly indicated that a sampling intensity of 20 per cent (i.e., 1 strip in 5) of the whole forest was fairly certain to give an estimate within 5 per cent of the truth, a sampling intensity of 10 per cent (i.e., 1 strip in 10) would have given estimates within 10 per cent of the truth, and a sampling intensity of 5 per cent (i.e., 1 strip in 20) within 15 per cent of the truth.

Although for both the Indian and American data examined, systematic sampling proved more precise than stratified random sampling, Dr. Finney recommends the latter method of sampling. This is because it is impossible to make any fully reliable estimate of the sampling error from the systematic sampling results themselves. Statisticians have, however, taken up the question in right earnest as is clear from the profound study recently made by Dr. Yates.

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THE USE OF D.D.T.

A word of caution

Not being an entomologist nor a chemist, the writer feels bound to great caution in his remarks. He has however been watching research on D.D.T., published in scientific journals such as "Nature". Such research seems to indicate that the toxicity of D.D.T., varies with the animal (including insects) that come into contact. Work does not appear to have been done on useful insects such as the Lac insect and Honey bee ; nor on the insects that perform the pollination of entomophilous plants that produce fruits and other valuable products. There appears no guarantee that such useful insects will not be eliminated or reduced by the use of D.D.T., on large areas, especially as it is known that the effects of D.D.T., persist for about three weeks. Lest we are faced with the problem of lack of food at a future date due to the reduction in numbers of useful insects it behoves us not to rush to the use of D.D.T., until careful complete research has shown that D.D.T., destroys only the insects we wish to destroy. As the effect of Pyrethrum insecticides persists for comparatively much shorter periods than that of D.D.T., and as Pyrethrum can be grown as a cottage industry in Kashmir, Nilgiris and other suitable localities, the use of Pyrethrum insecticides with or without rotenone may be preferable.

M. S. RAGHAVAN.

EXTRACTS

FOREST SPRAYING AND SOME EFFECTS OF D.D.T.

Department of Lands and Forests, Ontario. Canada, Division of Research, Biological Bulletin Fo. 2, 1949, pp. 174.

In this bulletin is recorded a series of well planned experiments (conducted between 1944–46) with D.D.T. applied as Spray from Aeroplanes or from ground apparatus. The object was to determine the effectiveness and economy in the control of SPRUCE BUDWORM epidemic in Forests of Ontario, Canada.

Before launching into large scale experiments, initial tests spray experiments were applied

from air and ground and effects of such spraying on various forms of animal life (aquatic and terrestrial) were first checked up by competent biologists. These initial tests showed a satisfactory kill of SPRUCE BUDWORM; and there was no disastrous effect on forest life at concentrations at which budworm was killed except some Amphibious and Acquatic insects.

Two concentrations were used for spray solutions, namely

(1) 1 lb. of D.D.T. 2.75 pints of Velsical, 4.61 pints kerosene = 1 gall. spray solution.

(2) 1 lb. of D.D.T. 2.79 pints of Xylol, 4.86 pints Fuel oil = 1 gall. spray solution.

The significant effect on the budworm was considered important enough to undertake large scale aerial spraying operations using D.D.T. solutions. A tract of 100 square miles containing valuable stands of spruce on which the budworm infestation was found severe and reaching its climax was selected as the initial target. The assumption was that if the population of budworm could be destroyed or appreciably reduced without injurious effect on other forest life the progress of infestation might be arrested without destroying the stands.

There were certain major problems that were first to be faced. The problem of securing suitable air-craft was solved with the help and co-operation of the Royal Canadian Air Force. The next problem was the design and installation of simple and effective apparatus for spray distribution. This was overcome by designing special spray tube. Third problem was to apply the spray during the short time the insects were in a vulnerable condition.

Equally important problems were in regard to keeping stocks of chemicals available without interruption, viz., D.D.T., solvents of D.D.T., diluents of D.D.T.; proper knowledge of preparing spray solutions; arrangement of electric power; large volume steam pumps to mix the ingredients with diluents; steam for heating solvents; a central depot for preparing solutions; apparatus for mixing ingredients; delivery of prepared solutions to air-craft; insecticidal capacity of air-craft; air-post facilities; photographic arrangements and radio equipments; maintainance of meteorological station; first aid equipments; and finally co-operation of various experts and organizations.

It is regretted that no statistics on the net financial loss to spruce forests through budworm epidemic are available in the bulletin.

In 1945 the D.D.T. spray was applied at 1 lb. per acre over 100 square miles. It gave a kill of 50–60% of budworm and the damage done by the insects was very much reduced. Before aerial operations were available, small scale experiments were conducted to get some idea of toxic action of D.D.T. In these tests sprays were applied with hand spray, directing the sprays over tops of trees so as to fall on to foliage, applied at 5–8 galls. per acre. The trees treated ranged from 10–12 feet in height and were heavily infested with the Budworm 98–100% kill was achived within 6 days of spraying.

In 1946 again spraying was undertaken using various concentrations, ranging from 2–4 lb. per acre but using 2 lb. of D.D.T. per acre over most of the area. More than 70% kill of budworm was achieved. No disastrous effect was observed on other forms of forest life. No injury was observed on foliage of coniferous trees; injury to foliage of deciduous trees (birch, willow, maple, etc.,) shows certain variation such as slight to severe marginal spotting on leaves. The spraying was usually done in the early morning, and the aeroplane flown at 50 feet high, at 65–76 m.p.h. air speed. The spray clouds descend through forest canopy as a very fine mist with fine droplets on foliage. Pupæ and eggs did not directly succumb from spraying but subsequent emergences from them died; larvæ were directly affected and moths came down fluttering to ground and died subsequently.

The entire cost of 1946 spraying operations was $ 81,295.04 which comes approximately to 2,69,899.53 rupees at predevaluation rate, which includes all expenditures that was necessary in carrying out the spraying operation.

The total quantity of D.D.T., it may be mentioned, used was 64,500 pounds; the total quantity of solvents used was 10,206 Imperial gallons Velsical AR 50 and 11,876 gallons Xylol; Velsical AR 50 dissolved 29,700 pounds of D.D.T. and Xylol dissolved 34,800 pounds of D.D.T. The total quantity of diluents used was

17,105 gallons, Kerosene oil and 20,375 gallons Fuel oil.

According to the bulletin the Budworm epidemic in 1946 was checked at a (tremendous) cost of Rs. 2,69,899.53 = $81,295.04. It would be interesting to know what are the after effects of 1946 D.D.T. spraying.

Can this sort of expensive control operation be undertaken in other countries ! In India there are two outstanding problems of a similar nature, viz., (1) Teak defoliators *Hybloea puera* and *Hapalia machaeralis* in South India and (2) Deodar defoliator *Ectropis deotarœ* of Coniferous forests in the hills.

Unfortunately no statistics are available in India on the net financial loss caused by these two pests in order to justify undertaking of similar large scale operation.

Perhaps we may think to take a lead now by devising small scale trial experiments in Teak and Deodar forests.

N. C. CHATTERJEE.

REVIEW

FOREST PATHOLOGY by JOHN SHAW BOYCE M.A., M.F., P.H.D.

Professsor of Forest Pathology, Yale University, Second Edition, McGraw-Hill Book Company Inc., New York, 1949. *Price 6–0–0*

The book is based on the research and information on forest and plant pathology contributed by about three hundred workers all over the world covering a period of three quarters of a century. The first edition was published in 1938 which underwent four impressions in a compatarively short period. The first book on the same subject was published in 1931 under the title "An Outline of Forest Pathology" by Dr. Earnest E. Hubert. Dealing with the same subject is a third book "Pathology in Forest Practice" by Professor Dow Vawter Baxter published in 1943.

Forest Pathology which principally deals with the diseases of woody plants of forests and also takes into account the decay of timber and deterioration of forest products is a daughter science of plant pathology and applied mycology. But the extension of its scope to forest products have made it more attractive and important than the nucleus from which it developed. Like every applied science the field of application of forest pathology is ever expanding. This is shown by the growing demands of a treatise like this. The publication in the last 12 to 15 years of three well written books, a large number of subsidiary texts on decay of timber and forest products and monographs on tree rusts and other fungi connected with tree diseases are definite proof in support.

The fact that the first edition of Professor Boyce's book underwent four impressions during wartime is significant of its popularity and demand by the increasing number of workers in this field of recent development. Also a large amount of new information accumulated during the 10 years, mainly connected with the exploitation of timber resources and intensive utilization of forest products for the purposes of war which had to be incorporated, necessitated the publication of a new edition.

The book is compiled in twenty-one chapters and two appendices (containing a description of fungicides and a list of common names of plants used with scientific equivalents) and index (Prefix x + 550 pages.) The book can be broadly considered under 7 main parts,

namely, general mycological text, non-infectious diseases, seedling diseases, pathology and tree diseases, decay of wood and wood products, principles of disease control and appendices and index. The book is illustrated with 216 illustrations consisting of line drawings, diagrams, tables, graphs and half-tone photographs. Some of the photographs have been enlarged and reproduced better than in the previous edition. Also the size of the book has been increased from $6\frac{1}{2}$ inches by 4 inches to the standard McGraw-Hill size 7 inches by $5\frac{1}{2}$ inches.

Besides the above there are some general improvements on the earlier edition namely, the use of inverted comma to technicalize important mycological and pathological terms and of the names of hosts and parasites to more recent ones to make the book up-to-date. Information about many diseases which was vague in the previous edition has been more definite in the present one. There are many new fungi unrecorded in the previous edition, but introduced in the present one. Portions are recast, altered, repetitions avoided, paragraphs split up and deleted and new paragraphs added for better reading. A very welcome change to one who is not an American is that citations of too many American instances have been avoided. Citations of names of many American forests in the previous edition have also been reduced. This adds to the international outlook of the present edition.

The first three chapters consist of introduction, discussion on the causation of fungus diseases and a simple taxonomic description of different groups of fungi. The chapter which interests a pathologist, follows next (Chapter IV) and deals with non-infectious diseases and patholigical symtoms produced by high temperatures (sun scald), low temperature (frost injury, frost ring formation, frost canker, frost scars, etc.), water deficiency (drought, heat cracks, winter drying, etc.), water excess, nutritional defects, injury due to industrial process (smoke and smelter fumes injury), salt spray, mechanical injury (fire scars, ice storms, hailstones and lightening injury, etc.). These have been discussed with a complete bibliography referring to the recent works of Swingle (1944), Hepting (1945), Jackson (1945), Hansborough (1947) Hawboldt (1947) and Pamerleau (1944).

The seedling diseases have also been considered into two catagories, namely, non-infectious and fungus diseases. Under non-infectious diseases the above factors have been considered from the point of view of protection. Under fungus diseases, damping off, root rot, snow blight, moulding, smoothering, spots, etc., due to the attack of fungi of lower orders (Phycomycetes and Fungi Imperfecti) and Ascomycetes and a few Basidiomycetes have been discussed. For controls of seedling and nursery diseases selection of disease free seeds, proper planning of nursery and selection of nursery sites have been given the utmost importance. Although the list of causal agencies is not complete and reference has been made to pathogenes known in United States of America the items of control practically cover the whole range of such diseases. The root diseases due to shoe-string fungus [*Armillaria mellea* (Vahl.) Quel.] has received adequate recognition (Chapter VI). Contributions on the pathology of root and buttrot fungus [*Fomes annosus* (Fr.) Cke.] from United States of America and Europe are mostly of recent years (1930 to 1946), the readily accepted theory of root wounds and frost injury in the butt region have been discussed with a few remarks on control methods. A short description of root-diseases due to other organisms of the family Basidiomycetes, Ascomycetes, Phycomycetes, Fungi Imperfecti and virus (Phlœm Necrosis of American elms—Swingle 1942, Tucker 1945) have been given. A short account of mycorrhiza has also been included.

The foliage diseases have been described in two parts, i.e., of hardwoods (Chapter VII) and of conifers (Chapter VIII). The former include leaf spots, tar spots, twig blights, powdery mildews, sooty moulds, rusts, blisters, flower and fruit rot, deformations, scab and canker of tender shoots caused by various pathogenic fungi including rusts, Ascomycetes, Fungi Imperfecti, etc., a short but comprehensive account being given.

Under the latter, are included distribution, pathology and biology of leaf blights and needle casts due to various ascomycetous fungi such as cedar leaf blight due to *Keithia thujina* Durand, needle cast of Doughlas fir due to *Rhabdocline pseudotsuga* Syd., needle cast of balsam fir due to *Hypodermella nervata* Darkar, needle cast of pines due to *Lophodermium*

piniastri (Schrad) Chev. *L. juniperinum* (Fr.) de Not., *Hypodermella concolor* (Dearn.) Darkar of jack and lodgepole pines have been given, besides several others under the miscellaneous foliage diseases. Under needle rusts distribution, life-cycle, pathogenecity of cedar and juniper needle rust (15 species of *Gymnosporangium*) have been considered in detail because damage to the pomaceous hosts is often serious in the West Coast, North Central and Lake Region States of U.S.A. ; and in the provinces in the North Central and Western Canada this disease has become of economic consequence as valuable orchard trees are attacked by "cedar apple" rusts. Control measures include spraying the orchards and isolation of the alternate host. Besides *Gymnosporangium*, about 70 species of needle rusts most being heterœcious species have been described, under hosts, such as Pine Needle Rusts (*Melampsora*, *Melampsorrella*, *Uredinopsis* and *Milesia*) Hemlock Needle Rust (*Pucciniastrum*) and Larch Needle Rusts (*Melampsora*). Distribution and biology have been given, keys to the well-known American species also being included. Also included in the list are unrelated species referred to by *form genera Peridermium*. In the description the classical works of various well-known uredinologists both American and European (Tubeuf, Klebahn, Arthur, Farlow, Jackson, Faull and his collaborators) have been referred to and cone rusts (*Cronartium*) described.

The stem rusts of conifers which cause "witches'-brooms", swellings, blisters and galls of stem and cause die-back or kill young trees outright are of greater economic importance ; and have received detailed treatment in two sections. Distribution, biology and pathology of ten heterœcious stem rusts, except in case of Woodgate Gall Rust the identity of which is not known and of Western Gall Rust [*Cronartium harkensii* (Moore) (Meinecke)] which is suspected to be identical with Eastern Gall Rust (*Cronartium cerebrum* Hedge. and Long = *Cronartium quercuum*), have been described in details. We owe our knowledge of the rusts which perenneate in the stems of conifers to the American workers and much of the work has been done in the Experimental Station laboratory distributed in various states of U.S.A. and provinces of Canada by pathologists and foresters who co-operated to tackle the problem from every angle. Nothing could be more welcome to the students of forest pathology than the complete and up-to-date supplementary information at the end of each chapter. One chpater has been alloted to the White Pine Blister Rust in the U.S.A. which is introduced from Europe. The amount of damage it caused to the pines, endemic as well as introduced, made the problem of paramount importance to the States for a quarter of a century. This rust deserves a special and prominent reference. References have been made to the work of about one hundred workers in the States and Canada ; and a direct method of control has been successfully worked out. The White Pine Blister Rust, the Chestnut Blight Disease and Dutch Elm Disease have strengthened the hands of American Phytopathologists in enforcing quarantine laws.

This is followed by two chapters on the stem diseases of conifers and hardwoods. In the former canker due to Ascomycetes such as canker of pines due to *Tymponis* species, canker of larch due to *Dasycypha Willkommii* (Hart.) Rehm and other species of *Dasycypha*, and due to Fungi Imperfecti such as *Macrophoma* species, *Phomopsis lokoya* Hahn. have been described and symptoms and etiology detailed. These diseases attack trees growing under unfavourable conditions in the virgin forests of the United States, the descriptions of these parasites therefore have been given from the point of view of the American workers. None of these diseases, however, has been recorded in India.

In dealing with the stem diseases and cankers of hardwoods which are of more serious consequence than those of conifers the author has added many new diseases. These disease are difficult to diagnose and still more to control unless etiology is known. Protective measures which were merely suggestions have now become definite with the increasing knowledge of the etiology and biology of the organisms. This chapter has considerably more information than that of the previous edition.

Amongst the Fungi Imperfecti, Dothichiza and Septoria Cankers of oak and chestnut, Sphæropsis Cankers of oak ; and amongst the Ascomycetes Black Knot of cherry [*Dibotryon morbosum* (Schw.) T. & S.], Didymosphæria Canker of alder, Cytospora Canker of willow,

Neofabræa canker and Hypoxylon Canker of popular and Eutypella Canker of maple have been described. Nectria Canker (*Nectria galligena* Bres.) of yellow poplar and magnolias and Beech Bark Disease (*Cryptococcus fagi* Baer. followed by *Nectria cocina* var. *faginata*) with symptoms and etiology have been described in detail. Lastly, the Chestnut Blight or Endothia Canker of chestnut has been described under various sections, such as history, distribution, hosts, damage, epidemiology, symptoms, causal agency and control. This section has been presented in a somewhat more condensed and altered form than in the previous edition. This fungus was formerly considered as a dangerous parasite of forest *cum* horticultural plants of American importance. The chestnuts including several species and varieties and their hybrids are now recognized to be important endemic timber trees of many of the warm temperate regions. Besides China and Japan of far Eastern Asia they are important timber trees of various warm countries of Europe like Portugal, Spain, Italy, Czchoslovakia and Balkan Provinces, and the chestnut disease survey points out that Endothia Blight is gradually spreading in all these countries. Horticultural, genetical and pathological experiments are now carried out in almost every country where chestnuts are regarded as important timber trees to fight out this pest. The Chestnut Blight Disease of America is now a wider problem for the geneticist and tree pathologist as it affects vaster regions of Europe and Aisa, and the information regarding all aspects of the problem will be useful for the workers concerned in this field.

Also from the point of view of practical plant pathology and its application to forest protection the subjects that can be profitably investigated and appeal to a practical tree doctor are included in the study of stem diseases and decay due to parasites and their prevention. Likewise the study of the causal organisms producing rot in timber would appeal to a timber doctor with the object of formulating the methods of prevention. Consequently in recent years more attention has been paid to this side of forest pathology, i.e., the etiology than to work out the methods of prevention which have been left to a specialized or selected group of workers. This is reflected by a large number of publications investigating the modes of infection, epidemiology, etiology, causal organisms, etc., listed at the end of the chapters.

Under Stem Diseases non-infectious and infectious galls have been discussed in two chapters. Short accounts of dieback of hardwoods due to *Nectria cinnabarina* (Tode) Fr., of pines caused by *Cenangium abietis* (Pers.) Rehm., of butternut by *Melanconia jugulandis* (E. & E.) Graves and of other miscellaneous hardwoods due to various species of Fungi Imperfecti have been given. A complete description of Dutch Elm Disease has been given under several sections, namely, history and distribution, hosts, damage, symptoms and the causal agency from the point of view of American workers. For protection of elms, sanitation against the bark beetles that spread the fungus, spray of technical D.D.T., dissolved in fuel oil or xylene with emulsifying agents in case of living tree have been recommended, strengths of various components for the preparation of the spray fluid having been given.

A concise description of American mistletœs with a key to the American species of *Arceuthobium* together with the host list have been given in Chapter XV. Protection methods have been discussed in detail from the pathological and silvicultural point of view for all types of forests including nursery stocks and virgin stands. At the end of the chapter some aspects of biological control have been discussed and a few enemies of mistletœs have also been referred to.

Further elaboration of Stem Diseases due to various hymenomycetous fungi which are regarded as facultative parasites and for brevity termed "decay" opens Chapter XVI which introduces timber pathology. The descriptions are concise but a full treatment has been given under each section which follows in succession such as Types of Decay, Gross Characters of Decay, Chemistry of Decay, Microscopic Charactess of Decay, Resistance of Fungi Causing Decay and Control of Decay.

Under section on microscopic characters of decay, the penetration of hyphæ through the cell-wall has been attributed to chemical action, the cell-wall being locally dissolved by enzymes, in advance of the actual passage of the hyphæ (Proctor 1941), and the enzymes being secreted solely by the tip of the hyphæ ; but when the bore hole is enlarged, enzyme secretion is not confined to the hyphal tip.

The machanical theory having no support has been abondoned. Further evidence supporting the chemical theory more strongly are the elongated bore holes orientating parallel to the long axis of the secondary walls of the fibres (Bailey and Vestal 1937; Tamblyn 1937). This phenomenon cannot be explained by mechanical theory.

The importance of isolation of decay and the examination of cultural characters which have been recently followed in the diagnosis of decay (Campbell 1938 ; Davidson, Campbell and Vaughn 1942 ; Robak 1942) have been emphasized. Special media which accelerate the formation of sporophores (Badcock 1943), oxidate tests with gallic and tannic acid in malt agar media and the guacum tests are useful recent additions.

Under the section "Control of Decay" methods of scaling and estimating decay in trees and logs have been discussed and the methods to calculate the volume of rot and sound timber in stands and timber have been given. This is a very important pre-requisite for practical training of staff employed in the timber trade. The author has considered decay in various American softwoods such as Western Conifers which include Doughlas fir due to *Fomes pini*, *Fomes laricis*, *Polyporus schweinitzii* and *Fomes roseus* ; sitka spruce due to *Fomes pini* ; western hemlock due to *Echinodontium tinctorum*, *Fomes emosus*, *F. applanatum* and *F. pini* ; white pine and lowland white fir due to *E. tinctorum* ; red fir also due to *E. tinctorum* ; western white pine due to *F. pini* ; ponderrosa pine due to *Polyporus anceps* and incense cedar due to *Polyporus amarus*. Data from various Canadian and American laboratories and references to well-known workers such as Bier, Foster, Salisbury, Weir, Lewis, Hubert, Englarth and author himself have been included. The importance of timber like sitka spruce which was used for aircraft during the second World War, red fir, ponderrosa pine, etc., not mentioned in the earlier edition has been stressed and decay tests included. Formation of the top rot of hardwoods and its relation to the incidence of wounds and rotten branches and the data from the works of Davidson and Campbell (1943) on Black Cherry Rot on the estimation of cull defects are recent additions.

The largest number of contribution on stem and timber decay in recent years are mainly from the forest products laboratories of Germany, Sweden, England, Canada and U.S.A. and also from the laboratories under many industrial concerns processing timber and wood-products and are referred to in Chapter XVII. The author has given a complete but concise description of some of the important American timber destroying fungi, namely, Red Ring Rot [*Fomes pini* (Thore.) Lloyd], Red Ray Rot (*Polyporus anceps* Pk.), white Trunk Rot [*Fomes igniaris* (L.) Gill], Brown Stringy Rot (*Echiniodontium tinctorum* E. & E.), Red Brown Rot (*Polyporus schweinitzii* Fr.), Balsam Butt Rot (*F. balsamsus* Pk.), Brown Trunk Rot [*Fomes laricis* (Jacq.) Murr.]. Besides short descriptions of about 80 species of hardwood and softwood decay have been given against 62 species in the previous edition and estimates of losses due to decay both in use and storage with data where available have been included. The section on dryrot has however been disposed off with short remarks on *Poria incrassata* (B. & C.) Curt. with a mention of *Merulius lacrymans* (Wulf.) Fr. The bibliography on the rots is complete and from all parts of the world.

The last three chapters are important from the point of view of timber industries, lumbering, utilization of forest products, etc., and subjects dealt with in sections under different categories are the Deterioration of Dead Timber (Chapter XVIII), the Deterioration of Forest Products : Decay (Chapter XIX) and Deterioration of Forest Products : Sapstains (Chapter XX). The author discusses the methods of salvage of killed trees, decayed and stained wood and wood products, which should be the main objective of every lumbering operation to save losses by salvaging material before any further deterioration sets in. The sound principles of lumber industry are based on secondary operations and salvage of the so-called waste material. Insect killed, fire killed, windthrown timber and slash, etc., add to the losses in these days when the rates of handling timber, labour and transports are climbing up sky-high.

As biotic factors are responsible for tremendous losses of timber resources in our tropical forests, the informations given in these three chapters should prove a very useful guide to our foresters, lumbermen and industrialists if the

basic principle involved is properly understood. Fire, insect and woodrotting organisms are considered as natural enemies of the tropical forests. We have no adequate means to stop them, but proper logging of insect-killed and fungus-decayed material would certainly save a fortune provided we are able to work up the proper schedule of deterioration set up at different stages so as to ascertain how long such timber could be left in the coupe at the time of the year when transport to the mills is not practicable. Fire is the greatest curse of our tropical and subtropical forests. We have no means to calculate the actual amount of loss to the forests caused by these agencies but the estimated loss is tremendous, running to many crores of rupees. The foresters, scientists and industrialists must combine to make the best of a bad job by salvaging the waste, and the science of forest utilization must prove its worth by finding out how the waste products should be put to the best use.

From the utilization point of view the natural resistance to decay due to the biproducts of plant metabolism such as tannin, volatile chemicals, colouring matters, toxic oils, resinous exudations (non-toxic but preventing penetration of wood destroying fungi), etc., have been considered. Under the section of decay of pulp wood and pulp, methods of hygienic storage, proper piling and chemical treatment to protect material for pulp have been briefly discussed. The loss to our pulp material (bamboo, in particular) is very high, due to the fact that sap stain is active in the monsoon for 4 to 6 months, and in some parts of the country at the time the material reaches the crushing mills appears carbonus. Storage is a difficult problem for the paper industries. To save this tremendous waste we should have more chemical protection of pulp material prior to monsoon when dry storage is almost impracticable.

Much work has been done by American workers, by Findlay (1939) Schaffer (1940, 1941), Lindgreen (1940), Champman (1940), Verrall (1939, 1941, 1946) and others in recent years on sapstain since the publication of Professor Boyces' book on Forest Pathology in 1938. Stains on wood products were regarded as minor defects in the timber, especially the blue stains of softwoods ; but now they are considered as one of the major handicaps of the marketing of finished wood products, which result more from reduction in grade than outright rejection; the loss is estimated at over 10 millions dollars in the United States alone. The chapter includes much information available on the control of sapstain (Schaffer and Lindgreen 1940) and chemical protection in dipping solution (Hartley 1945, Schaffer 1946) both as a laboratory test and in the lumbermills with *pre* and *post* seasoning processes.

Under the section "Decay of Structures", fungi causing decay of building and other permanent structures and methods to prevent decay have been summarized. The section on wood preservation has been unusally abridged but a complete reference to the subject has been annexed.

The author discusses the fundamentals of forests disease control in Chapter XXI under two categories namely, the control of native diseases and the control of introduced ones. The basic principle involved being different in two cases, the methods evolved have been justified by sound arguments and explained in lucid language. With the native diseases, sound silviculture, selection of sites, adjustment and judicial composition of the crop at the time of restocking, preference for mixed crops in place of pure stands in the second rotation or second cut stands, selection of seed, acclimatization of the species when introduced from one region to another, and lastly, the breeding of forest trees to improve resistance have been considered ; and merits and demerits discussed while trials of exotics in place of susceptible native species have been discouraged. Introduced diseases are infinitely more destructive and require more expensive direct measures. The author has quoted glaring instances of half a dozen pests introduced into the United States during the last 50 years, such as the Chestnut Blight Disease, White Pine Blister Rust, the Dutch Elm Disease, Willow Blight, Larch Canker, Beach Blight, etc. The lack of judgement in the initial stage to estimate the injurious capacity of potential parasites and delay in taking quick action against them have given them enough time to establish themselves on native American hosts. Also the unsatisfactory quarantine laws, which failed to exclude rigourously disease propagating stocks and forest products through which the diseases were introduced in the United States in the earlier parts of the cen-

tury, have been deplored. The slow method of investigating and cruising (estimating) the diseases at the time when they are first noticed have also been criticized. Finally the principles governing control of introduced parasites have been summarized and the views of Ditwiller (1929) and Fracker (1937) have been put forward. Public opinion has to be roused for sanitation, destruction of the diseased stock, eradication in an extensive control programme, and lastly, passing of legal enactments when persuasive methods fail, have been emphasized.

Although the control details aim at checking pests endemic and introduced of native American trees the basic principles are applicable to any country faced with such situations. We have fortunately no record of any introduced tree disease that has developed to a dangerous stage. The diseases of our evergreen and deciduous hardwoods and of the conifers in the Himalayas so far recorded are endemic ; and endemic diseases never develop to such dangerous proportions. Further direct control is rarely necessary or justifiable against native parasites. We have a large number of resistant hardwood species. As regards conifers, the Himalayan species though few, are sufficient for our home requirements, and except as a trial on an experimental basis there is little need to introduce exotics in India.

During the last world war it was a difficult proposition to safeguard the introduction of new diseases in any country involved in the struggle. We have records of *Trametes serials* and *Poria monticola* reaching our shores in a consignment of sitka spruce and Douglas fir timber. There is every likelihood of other parasites invading our country through agricultural and forest products ; and at this stage when we are in a state of reorganization, Professor Boyces remarks on the quarantine regulations should be more fully realized.

This book which is the only one of its kind will be invaluable for students and teachers of forestry, the forester, the silviculturist and private owners of small forest lands. This book will be equally handy to lumbermen and to those who invest in timber trade who will find useful information on how to cruise sound and diseased stock and how to salvage leftover material and save diseased trees and defective forest products from further deterioration. The complete bibliography is time saving to the students, as no other complete and up-to-date reference is available in this country.

K. B.

INDIAN HILL BIRDS by SALIM ALI, Pages lii + 188, with 64 illustrations in colour. Published by the Oxford University Press. *Price 20–0–0*

Salim Ali needs no introduction to bird lovers in India, and his latest publication, "Indian Hill Birds" comes as a boon to bird watchers in the hills. It is a companion volume to the author's "Book of Indian Birds", and the two together should form the easiest introduction to studies of bird life in the country. The readers will appreciate the excellent get up and the handy size of the volume.

The numerous coloured plates (artist, G. M. Henry) help to make the book attractive and very useful, especially to the beginner, who is attracted primarily by the colours of the plumage of the birds he comes across during his wanderings. Another feature that beginners will welcome is the simple key adopted. The key to the identification of birds is based on such field characters as are readily noticed and easily interpreted, e.g., "Birds with prominent tails", "Birds with prominent crests", "Brightly coloured birds" etc. The descriptions of birds are made out in an easy, readable style and include numerous original observations on nesting habits, etc.

The geographical distribution of the birds dealt with, is rendered in a tabular form and rainfall and physical maps of India are also included (given on the inside of the covers). These will be found useful by the more serious students of bird life.

That every species described in the book is not illustrated (in colour) may appear as a drawback, but as the author himself has mentioned in the preface, the number of coloured plates had to be limited, owing to the high cost of coloured printing.

We welcome Salim Ali's "Indian Hill Birds" as a timely addition to popular publications so badly needed to stimulate active interest in nature studies.

C. A. R. B.

ERRATA

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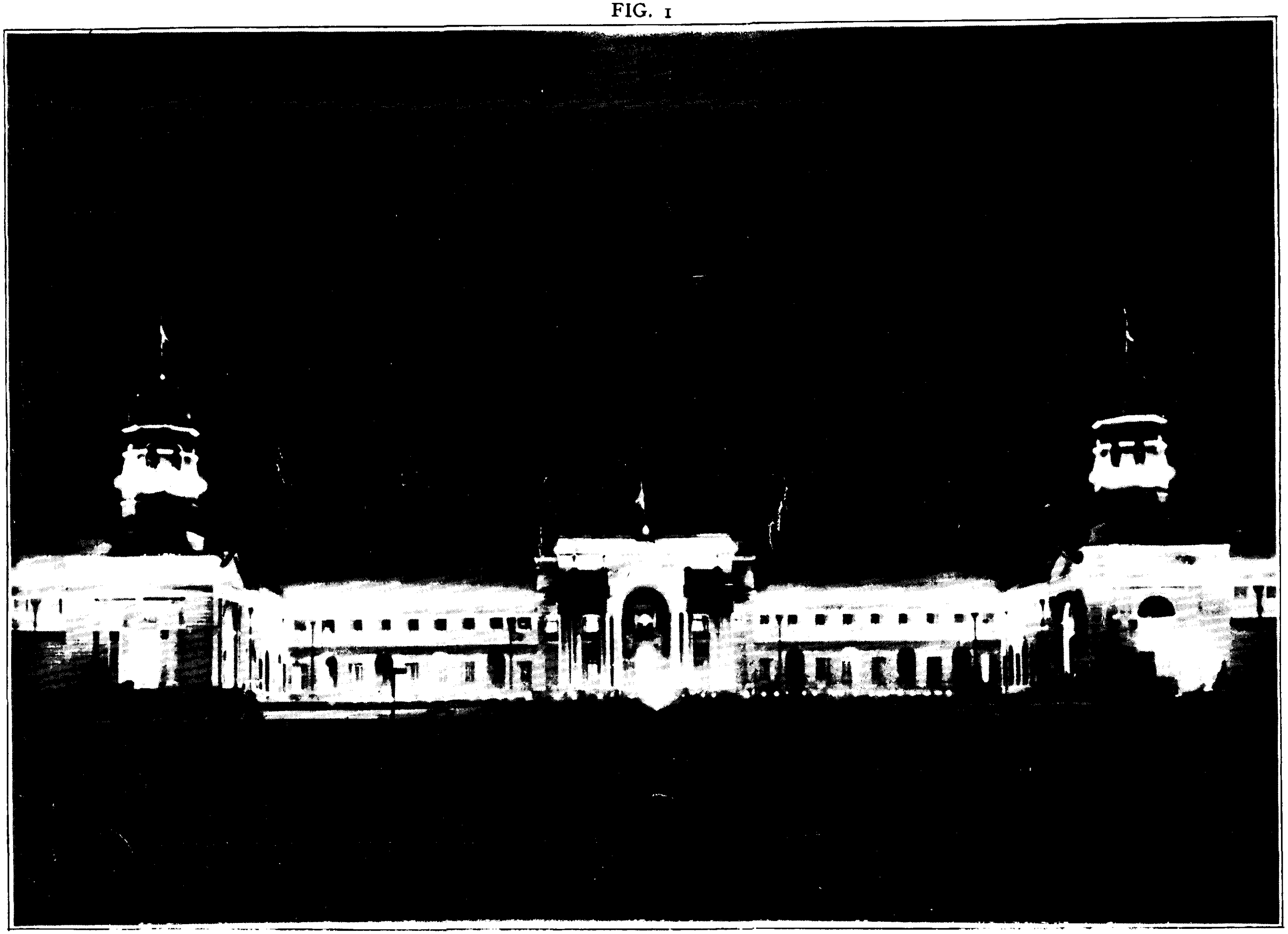
FIG. 1



The Forest Research Institute and Colleges illuminated on Republic Day.

FIG. 2

Mr. C. R. Ranganathan, hoisting the National Flag; Mr. M. B. Raizada, Chairman of the Celebrations Committee, is seen on his left.

FIG. 3

The gathering at the Flag Hoisting Ceremony.

THE THIRD WORLD FORESTRY CONGRESS

BY C. R. RANGANATHAN, M.A., I.F.S.
(*President, Forest Research Institute and Colleges*)

In pursuance of a proposal adopted by the Third Session of the Food and Agriculture Organization of the United Nations and at the invitation of the Government of Finland, the Third World Forestry Congress was held at Helsinki from 11th to 19th July 1949. Although the F.A.O. sponsored the Helsinki Congress and took an active part in its organization and direction both in the preparatory stages and during the Sessions, it was, as its name implies, a successor to two earlier Congresses, both held prior to the formation of the F.A.O., the first in Rome in 1926 and the second in Budapest in 1936. The World Forestry Congresses are thus an institution distinct from the F.A.O.

At the invitation of the organizing committee, the Government of India decided to send a delegation to the Congress and nominated C. R. Ranganathan, President, Forest Research Institute and Colleges as its sole delegate. The following 29 countries were represented at the Congress :—Argentine, Australia, Austria, Belgium, Brazil, Canada, Ceylon, Czecho-Slovakia, Denmark, Finland, France, India, Indonesia, Israel, Italy, Mexico, Norway, Netherlands, New Zealand, Pakistan, Poland, Russia, Sweden, Switzerland, Turkey, United Kingdom, United States and the occupied areas of Germany and Japan. Representatives of the following international organization were also present :—

(1) The United Nations and its Economic Commission for Europe.

(2) The Food and Agriculture Organization.

(3) The International Union of Forest Research Organizations.

(4) The Scandinavian Forestry Union.

Over 400 ordinary members and nearly 130 associate members attended the Congress.

Before the Congress session opened officially, delegates were given the choice of taking one of eleven three-day excursions to various parts of Finland to see something of Finnish forests and wood-based industries. Each of these excursion parties was in the charge of an experienced Finnish Forest Officer and an interpreter. These excursions provided an excellent opportunity to delegates to form an estimate of the importance of forestry in the Finnish economy, and the high state of development of forestry and forest products industries as well as to make acquaintance with the Finnish people and their land of sixty thousand lakes.

A detailed description of the forests and factories seen during the excursion would be out of place here. Certain broad facts may, however, be of interest.

Out of a total *land* area of 75·49 million acres, forest land accounts for 53·52 million acres thus forming 71% of the land area ; (67·8% productive forest, 3·1% non-productive forest). Some idea of the very numerous lakes distributed all over the country and the resulting damp or swampy conditions prevailing is given by the fact that the fresh water area of Finland is 7·81 million acres (9·4%) against the land area of 75·49 million acres (90·6%).

The growing stock consists of pine (*Pinus sylvestris*) 45·5%, spruce (*Picea excelsa*) 32·2%, and birch (*Betula verrucosa*) 18·8%. Small quantities of aspen (1·9%) and alder (1·6%) also occur. Birch is thus the *only* hard wood (broad leaved) tree found which is of economic significance. A variety known as "curly birch" which occurs in limited quantities is greatly prized for its ornamental wood and fetches high prices. The Scots pine is valued rather more than the spruce and is favoured as against the latter.

Silviculture presents hardly any problems, such as face us in India. The composition of the forests is uniform to the point of monotony. Natural regeneration is effected mainly by shelterwood fellings, the strip system being commonly adopted ; so prolific in many sites is the natural reproduction of spruce that it is aften a weed of cultivation.

Two points about Finnish forests strike the visitor from India forcibly. One is the relatively small size of the trees ; trees over 18″ in

diameter are uncommon and over 24″ exceptional. The sawmills, plywood factories and wood using industries are accordingly geared to the utilization of small logs. The second point is the exceptionally good form of the trees, which are always straight grown and round. This results in reduction to a minimum of waste in conversion and in full utilization of the log.

Owing to the numerous inter-connected lakes, to which reference has been made, the common method of timber transport is by floating logs in rafts. Timber floating is a highly organized co-operative industry. In recent years, however, motor transport of logs has made considerable headway.

During the excursion the forests in the neighbourhood of Aulanko, Hämeenlinna, Evo, and Vesijako were visited. The following factories and institutions were also seen :—

Osuustukkukaupan Puu Oy's Sawmill and Wood Processing Plant at Hämeenlinna.

Yhtyneet Paperitehtaat Oy (Paper factory) at Valkeakoski.

Säteri Oy (Artificial fibre plant) at Valkeakoski.

Evo forest school (for forest foremen) which is the oldest forest school in Finland.
Plywood and Blockboard Factory at Heinola.

The Finnish Plant Breeding Station at Ruotsinkyla and the Sawmills and Prefab Factory at Rihimaki were visited during the course of the Congress.

The Congress was opened on 10th July by Mr. K. A. Fagerholm, Prime Minister of Finland. The President of the Finnish Republic, H.E. Mr. J. K. Paasikivi welcomed the delegates. The plenary sessions of the Congress were held in the University Buildings, while the sectional and committee meetings were held in the imposing Forestry Building, where a special post and telegraph office and an excellent restaurant had been installed and special banking and exchange facilities provided.

The work of the Congress was divided into five sections :—

I Silvics and Silviculture.
II Forest Surveys.
III Forest Economics, including Forest Policy.
IV Forest Utilization.
V Forest Industries.

Professor Eino Saari of Finland was elected President of the Congress, while Mr. C. M. Granger of the U.S.A., Mr. T. Petrov of Russia and Mr. A. Fjelstad of Norway were elected Co-Presidents, the last named *honoris causa*. The Congress also elected five Vice-Presidents. India and Indian forestry were honoured by the election of the Indian delegate as a Vice-President, the other four being from Brazil, France, the United Kingdom and Sweden.

Members of the Congress were alloted each to one of the five sections, according to their own choice, for purposes of discussion. The Indian delegate preferred to retain his freedom of action, being interested in the subjects discussed in all the sections and was accordingly not attached to any section. He took part in the discussions of all sections, except section V, and contributed to the drafting of many recommendations, especially the General Recommendations on Policy (items 15 and 16 of the General Report of the Congress).

Discussions were based on the following general and special papers contributed to the various sections :—

SECTION I.—*Silvics and Silviculture*

General Papers.—Development and Silviculture of Tropical Virgin Forests : Paulo F. Souza (Brazil).

Biology and Technique of Afforestation : H. G. Champion (United Kingdom).

La Reboisement et la Protection du Sol : Guglielmo Giordano (Italy).

Forest Genetics : C. Syrach Larsen (Denmark).

Special Papers.—Catchment Areas and Water Supplies : E. P. Stebbing (United Kingdom).

Alpine Bomboo Forest in East Africa : G. E. Alvino (Italy).

Developpement et Traitement Silvicultural des Forêts vierges dans les Tropiques : R. Sevandono (Indonesia).

Jardinage Cutting in Poland : E. Ilmurzynski (Poland).

Ecological Groups of Tree Species and Silviculture : Erkki K. Kalela (Finland).

On the Regeneration and Raising of Spruce and Birch Forests on drained Peat Soils in Finland : S. E. Multamäki (Finland).

Influence of Forestry on Soil Fertility : V. T. Aaltonen (Finland).

The Germination of seeds with particular reference to Forest Seeds : C. Castellani (Italy).

Utilization of Air Planimetria for applying hydrogeological control : Duilio Cosma (Italy).

La Reforestation des Landes en Campine belge : A. Galoux (Belgium).

The Biology and Technique of Afforestation : A. H. Gosling (United Kingdom).

Biology and Technique of Afforestation : Olli Heikinheimo (Finland).

Afforestations dans les Pays-Bas : A. H. Memelink (Netherlands).

Sur la Reconstitution des Forêts : J. Peter-Contesse (Switzerland).

Le Pin Sylvestre dans la Calabre : Bruno Da Ponte (Italy).

La Question du Peuplier : Ph. Guinier (France).

Seed Plantations—their Structure and Genetic Principles : Ake Gustafsson (Sweden).

Forest Genetics in the Netherlands : G. Houtzagers (Netherlands).

Experiments and Results of ten years Breeding Experiments at the Sweedish Forest Tree-breeding Association : Helge Johnsson (Sweden).

The Problem of Races and Polyploids of Forest Trees, as also the Problem of Trees and Types as Genetical Problems in Forestry : J. Karpinski (Poland).

Forest Genetics in Finland : Risto Sarvas.

SECTION II.—*Forest Surveys*

General Papers.—The Methods Employed in the National Forest Survey of Great Britain 1947–49 : F. C. Hummel (United Kingdom).

Different Survey Methods of Large Areas: Aerial Photography : H. E. Seely (Canada).

Forest Surveying by Ground Survey : Y. Ilvessalo (Finland).

Definition of Increment on Large Areas ; Maksimilian Kreutzinger (Poland).

Co-ordination of Forest Survey Data for Large Areas : Edward C. Crafts (U.S.A.).

Special Papers.—Aerial Photographs for Forestry Purposes : Duilio Cosma (Italy).

Aerial Survey and Photo Interpretation in Australian Forestry : D. A. N. Cromer (Australia).

Aerial Photography in Forest Surveys in Finland : K. G. Löfström (Finland).

Methods Employed in the National Forest Survey of Great Britian 1947–49 : W. H. Guillebaud (United Kingdom).

A Method of Analysis of the Wooded Areas and Forests : Giovanni Quatrocchi (Italy).

Growth and Yield of Japanese Larch in Denmark : Mogens Andersen (Denmark).

Rapports entre la Quantité des Aiguilles et l'Accroisement chez des Epicéas de la Forêt Jardinée dans Diverses Stations : Hans Burger (Switzerland).

Research of the Wood Growing Rate of Chestnut Trees : S. Federico (Italy).

Dependence of Volume Increment upon Thinning Grade and Variations of the Latter : J. A. Lovengreen (Denmark).

Forest Survey in Indonesia : D. A. Boon & M. von Bottenburg (Indonesia).

Forest Surveys : Erik Hagberg (Sweden).

SECTION III.—*Forest Economics including Forest Policy*

General Papers.—Economics and Policy of Exploiting Virgin Forests in the Tropics : J. F. Kools (Netherlands).

Politique de Reboisement et Implications Economiques : Jean de Vaissiere (France).

Relations of Forestry to Agriculture in Rural Economy : Gabriel Iby and Andrew Madas (Hungary).

Measures for Ensuring Sustained Yield in Forestry : Hans H. H. Heiberg (Norway).

Employment and Unemployment in Forestry : Hardy L. Shirley (U.S.A.).

Special Papers.—Economics and Policy of Exploiting Virgin Forests : V. Lintonen (Finland).

The Statistical Method and the Problems of Forest Economy and Policy : Eugenio D'Elia (Italy).

The Policy of Reafforestation on the East African Highlands : Alberto Hofman (Italy).

Principles for Silvicultural Planning : Dreszer Leslaw (Poland).

The Problem of Afforestation Investment Policies : Wiktor Ropelewski (Poland).

Politique du Reboisement et Implications Economiques : J. A. van Steijn (Netherlands).

La Politique de Reboisement des Terrains Incultes et son Caractère Spécial : Jaakko Vöry (Finland).

Relation of Forestry to Agriculture in Rural Economy : H. C. Beresford-Peirse (United Kingdom).

Forestry as Related to Agriculture in the Rural Economy of Indonesia : M. van Bottenburg (Indonesia).

Relations of Forestry to Agriculture in Rural Economy : S. Duschek (Austria).

Aménagement Sylvo-pastoral : P. E. Farron (Switzerland).

The Relation between Agriculture and Forestry : Zygmunt Glinka and Witold Piatkiewioz (Poland).

Relations of Forestry to Agriculture in Rural Economy : N. A. Osara (Finland).

Relations entre l'Agriculture et la Forêt dans l'Economic Rurale : Th. C. Oudemans & S. J. Halbertsma (Netherlands).

Windbreak in Shelterbelt Planting in the United States : J. H. Stoeckeler (U.S.A.).

The Problem of Dependence between Wood working Industries and Forestry in Poland : Florian Budniak (Poland).

Possibilities in Planning the Development of World Forestry : R. Fromer (Poland).

Forest Policy and Sustained Yield : A. Howard Cron (Denmark).

Some Features in Modern Swedish Forest Legislation : Folke Johansson (Sweden).

Measures for Safeguarding Sustained Yield in Indonesia : W. N. Mijers & R. Sevandono (Indonesia).

La Notion du Rendement Soutenu : Eino Saari (Finland).

Employment and Unemployment in Polish Forestry Management : Henryk Klimek (Poland).

Employment and Unemployment in Finnish Forestry : Y. W. Laaksonen (Finland).

SECTION IV.—*Forest Utilization*

General Papers.—Some Considerations on Methods of Job Investigations : J. Zehnder (Switzerland).

Organization de l'Exploitation Forestiere au Congo Belge : Pierre Staner (Belgium).

Special Papers.—Co-ordination of Distributors of Working Time and of Methods of Tool Study in Forest Work Studies : A. Hviid (Denmark).

Improvement of Efficiency in Logging : Matti Jalava (Finland).

Floating as a Form of Long Distance Transport in Finland : Ulf Lindgren & Pöntynen (Finland).

SECTION V.—*Forest Industries*

General Papers.—Prefabricated Wood House Construction in the United States : L. J. Markwardt & F. A. Strenge (U.S.A.).

Waste wood in the Forest and Industry : T. A. McElhanney (Canada).

Developments in the Field of Chemical Wood Utilization : Erik Hägglund (Sweden).

Conservation des Bois : Pavel Jirû and Rindolf Ille (Czecho-Slovakia).

Special Papers.—Prefabricated Wooden House Production in Finland : O. Rinkinen (Finland).

Rationalizing Methods of Wood Utilization and Manufacture : Franciszek Krzysik (Poland)

Expériences sur les Effets du Gemmage sur Pinus halepensis Mill et sur Pinus nigra Arnold : Dino Crivellari (Italy).

Contribution a l'Etude des Caractaristiques du Bois des Pens Suomis en Gemmage : Guglielmo Giordano (Italy).

Anatomical Alterations in the Wood of Aleppo Pine after Resin-tapping : Albina Messeri (Italy).

Activation Chimique de la Production Résiniere : A. Oudin (France).

Les Effets du Gemmage sur Pinus pinea L. et sur P. pinaster Sol : Alessandro de Philippis (Italy).

Development of Resining in Poland and Improving Methods of Collecting Pine and Spruce Resin from Standing Trees : Konstanty Szerbakow (Poland).

Protection of Wood against Fire : John Bryan (United Kingdom).

The recommendations of the Congress are attached to this Report as an Appendix. They represent the consensus of opinion among world forestry experts on a wide range of matters touching on forestry. If the recommendations are to serve a useful purpose, they must be brought to the notice of all governments, leaders of opinion and forest officers in India. In a foreword to the General Report of the Congress, Prof. Eino Saari, President of the III World Forestry Congress, says: "A World Congress is fruitless if the reports and recommendations prepared remain the knowledge of its participants only and collect dust on library shelves. The Third World Forestry Congress, recently terminated, was a forum where a number of the most prominent representatives of forestry and forest technology in the world met together in conference. They reached numerous conclusions which, however, will be of no practical value until they are made known to the Governments of every country, their parliaments and all the institutions and persons engaged in the conservation and utilization of forest resources.

APPENDIX

Recommendations of the Third World Forestry Congress

(Extract from the General Report of the Congress)

8. Among the many general and special reports concerning present day forestry problems presented in the Plenary meetings of the Congress and in the Sections, those prepared by F.A.O. deserve particular mention. They made a valuable contribution to the deliberations of the Congress by providing a basis for discussion and imparting direction to the debates. The effective co-operation of the experts of F.A.O. has also greatly facilitated the smooth running of the Congress.

9. The Congress has provided ample opportunity for foresters, industrialists and technicians from all parts of the world to meet, exchange views and experiences and to establish or renew personal relations which will stimulate and facilitate their work in the coming years. The work of the Congress has also revealed certain trends which become particularly apparent against the background of the first and second World Forestry Congresses and among which the developments set forth hereinafter seem worth recording.

The protection of forests from destruction, the establishment of forest inventories, the systematic management, the reduction of waste, the improvement of wood utilization, and raising the consumption of forest products in the interest of higher standards of living are objectives which have moved from the sphere of discussion to that of generally accepted truths.

10. The recognition of the role of forests in modern society is no longer confined to a small group of specialists. The importance of forests for soil conservation, their protective functions as well as the vital contribution which an increasing variety of forest products makes to modern economy are far better understood and appreciated by governments, industry, and by the public at large than at the time of the First and Second World Forestry Congresses. This important trend will facilitate the adoption and application of national forest policies.

11. One of the most striking changes of the past 13 years is the recognition of the principle that the management and conservation of forests and the manufacture and distribution of forest products must be regarded as an inseparable whole. It is the primary task of the forester to grow and produce both the amounts and the kinds of forest products needed by industry and other consumers for the optimum satisfaction of human needs compatible with the protective role of forests and the conservation of land productivity. At the same time it is the responsibility of technical research and industrial development to provide suitable outlets for all products of the forest crop and to adjust conversion methods and uses to the limitations and requirements of sound silviculture.

12. It was generally agreed that the evolution of forestry techniques and wood technology

had been considerably influenced by progress made in the scientific field.

13. It would be wrong and unrealistic to conclude that all is well in world forestry. Indeed much remains to be done. Further research is needed to widen the area of common forestry knowledge. The understanding of the role of forests among governments and the public is not always sufficient. Hence many countries still have no proper forest policy while in others the application of sound forestry principles is defeated by numerous obstacles. Co-operation between industrialists and foresters must be considerably strengthened. There is still much destructive cutting, which ought to be stopped.

14. Despite these shortcomings this Congress believes that since 1936 there has been progress in the right direction. Recognition of these short comings as well as the work of F.A.O., especially in implementing the specific recommendations which follow, should facilitate and speed further progress.

GENERAL RECOMMENDATIONS ON POLICY

15. *The Third World Forestry Congress* affirms its belief—

(*a*) that each country should have for its territory a forest policy aiming at the maintenance of a reasonable forest area and at the conservation and use of forests on the basis of continuous and improved production,

(*b*) that forestry legislation research, education of forest owners and workers, and training of a sufficient number of professional foresters and technicians—all in conformity with the constitution and structure of each country—constitute essential elements of such a policy.

16. *The Third World Forestry Congress* commending the work of the Food and Agriculture Organization of United Nations (F.A.O.) recommends—

(*a*) that F.A.O. prepare a statement of forestry principles for the consideration of Member Nations,

(*b*) that F.A.O. assist those nations which are now formulating their forest policy,

(*c*) that the annual Conference of F.A.O. explore whatever further steps Member Governments consider appropriate for the application of the principles stated above.

17. The discussions and resolutions of the Congress are classified and summarized according to the principal subject under review as follows :

I. SILVICS AND SILVICULTURE

A. DEVELOPMENT AND SILVICULTURAL TREATMENT OF VIRGIN FORESTS

18. The Congress recognizes that the natural laws regulating the evolution of vegetative associations are similar in tropical and other countries, that their evaluation should constitute the chief item of research in all countries, and that knowledge of them should everywhere form the basis of the silvicultural treatment of virgin forests.

19. Nevertheless the discussions which have taken place in the Congress have shown that different points of view exist as to the silvicultural measures to be applied in virgin tropical forests. whose essential features are their heterogeneous character and their poverty in species economically important or in good healthy condition.

20. Some members of the Congress who took part in the discussion considered the management of forests, other than those maintained for essential protective reasons and those which can with comparative ease be regenerated with valuable species, should be undertaken by the drastic method of clear felling, burning of felled materials, and replacing these old mixtures with homogeneous crops of high economic value, but not overlooking the need of maintaining soil fertility.

21. The other point of view expressed by the rest of the Congress Members was that, with the exception of small areas devoted to the establishment of plantations required to provide fuel, mine props, etc., drastic methods, such as clear felling, should be avoided owing to the risk involved in upsetting the delicate biological equilibrium, maintained for centuries, and thus result in a degradation of the tropical soils which are very susceptible to exposure. The supporters of this point of view consider that the increase in value of these poor crops by means of valuable species should be undertaken by enlightened silvicultural methods based on research into the best technical

treatment to be employed to obtain natural regeneration or by artificial means, of those species having a high economic value. It should be stressed that the introduction of species outside their natural habitat is accompanied by serious risks.

22. The Congress is of opinion that further extensive research is necessary to reconcile these two opposite opinions, either of which may prove to be the correct procedure depending upon the soils and climate encountered by tropical foresters. They consider that in the case where the first method (see paragraph 20) is put into practice without waiting for the results of research, a constant observation of the evolution and development of the crops thus artificially formed should be maintained, in order to prevent, by appropriate means (growth of an understorey, mixture of species, weeding work, etc.), the degradation of soils and the serious attacks of insects and diseases to which crops of this nature are susceptible.

23. On the other hand it was considered that if the second method was applied (paragraph 21), forestry research, to improve the crops, should be accompanied by technological research, with the object of assuring the use of as large a number of species as possible, and thus rendering economically sound the exploitation of this type of forest.

B. BIOLOGY AND TECHNIQUE OF AFFORESTATION

24. The Congress recognizes the importance of obtaining the fullest information on the synecology of forest communities and their status in relation to natural successions and climaxes. It suggests that this information might be collected by the regional centres set up by F.A.O. and made available, together with climatic and ecological data of value in afforestation work, particularly in connection with the introduction of exotic species.

25. It recognizes the importance of exact data on the evolution of the biological complex of forest soils. Further studies on root physiology and on the effect on the soil of a tree cover of the species most used in afforestation appear very desirable. The Congress recommends that the F.A.O. and the International Union of Forest Research Organizations be asked to give special attention to this subject.

26. It recognizes that the trees constituting climax forests are not always the most desirable from the economic point of view, but that on the contrary in certain cases non-climax trees are of very great technological value. It seems necessary that precise data on the action of non-climax trees on forest soils and the maintenance of their productivity be obtained.

27. The Congress desires to have more precise information on the effect of exotic species on natural forest communities and their sites. Such knowledge will provide guidance for the choice of species for afforestation, economic questions being also taken into consideration. An international documentation on this point and on the techniques of afforestation in the natural regions as well as on the various cases in which re-afforestation is an indispensable or complementary method for soil conservation seems to be desirable.

28. It emphasizes the importance of mechanization in afforestation work.

29. It seems that the general economy of a country is influenced by the proportional distribution of forest and cultivated land. This distribution has considerable influence on the total economy of water and the maintenance of soil fertility. Studies of the most suitable proportion between forests and cultivated surfaces under different climates seem to be desirable. Protection of soils and water economy, and the maintenance of climatic equilibrium justify in certain cases the creation of protective stands, even if the trees which comprise them have in themselves only slight technological value.

30. *Forest genetics.*—The importance of genetics as an indispensable basis of forest economy cannot be questioned at the present time. Experiments carried out on an international scale with the object of studying the different origins of any one species have given much information on the great variability of Linnean species. Exact knowledge with regard to the origin of tree seeds has become indispensable as well as sufficient information concerning the influence of external conditions on forests. In certain countries a survey of the seed crops, organized exchange of tree seeds and production of tree seedlings has been carried out. It seems to be desirable that such measures should be more generally adopted and that they should be put into practice on a basis of international co-operation.

31. The Congress emphasizes the importance of collaboration between governments in order to facilitate the exchange of seed and living plant material between scientific Institutions, and that special arrangements should be made for this purpose. It is desirable that the International Union of Forest Research Organizations should give assistance in this work. In view of the importance of such exchanges for the development of forest genetics and the delays in delivery caused at the present time by Customs fórmalities, etc.

The Congress recommends—

(*a*) that the government should take steps to facilitate the rapid exchange of seed and living plant material in small quantities between State Forest Services or Forest Research Institutes,

(*b*) that governments should study the possibility of exempting such material from customs duty when accompanied by an internationally standardized declaration emanating from the above mentioned services or institutes.

32. With the prospects of the progressive disappearance as a result of human activity, of trees of great genetic value, it seems now to be urgent to save such highly valuable plants within each tree species. Where practicable, each country should make an inventory of its most valuable stands, preferably in virgin forests, and if possible elite trees should be catalogued. The protection of these plants is most easily achieved by vegetative reproduction in special *arboreta.*

33. Research work in forest genetics should include the following points :—

(*a*) the study of hereditary characteristics, especially of growth, soundness and wood qualities within tree species, climatic races, ecotypes and forms,

(*b*) artificial pollination with a view to obtaining new and improved trees,

(*c*) cytological work for the identification and production of polyploids,

(*d*) vegetative propagation for the maintenance of certain types and forms,

(*e*) the work of identification of genotypes and study of environmental conditions and silvicultural treatments.

34. In the question of seed production it appears that the practical and inexpensive system of seed orchards is destined to provide tree seed in significant quantities. While awaiting the realization of this technical progress, it is recommended that, where practicable, the seed harvest should only be derived from recognized elite stands or trees.

II. FOREST SURVEYS

35. The general conviction was that the most effective basis of determining the yield available for utilization upon a sustained and progressive basis is the knowledge of growing stock and its increment, including problems of the accurate determination of these factors.

A. AERIAL FOREST SURVEYS

36. The Congress discussed at length the use of ærial photogrammetry in connection with forest inventories. It was agreed that this relatively new technique, which was still under development, was of great value, especially where surveys of large forest areas was concerned. Even with respect to small forests it has been used to advantage in some countries.

37. It was concluded that aerial photographs permit of accurate mapping of forest areas, and the sub-division of such areas into main forest types or stand-class groups. On the other hand, the amount of detail that can be secured varies with the nature and treatment of the forests and the quality of the photographs themselves.

38. Methods of estimating timber volumes from photographs are still the subject of research but, in general, volume determinations must be made on the ground. In any event, information regarding forest soils, growth, and other factors essential to the silviculturist must be secured by ground surveys.

39. *The Congress considers—*

that aerial photography provides a valuable aid to the preparation of forest maps and forest inventories and

that it is of special value for the surveying of large forest areas,

that, in the present stage of technical development, aerial surveys must be supplemented by examination of the forests on the ground, in order to secure additional information essential to forest management, and

that the choice of aerial survey methods in each country must be governed by the nature of the forests of that country and

40. *Recommends—*

(a) that all countries should review their forest inventory procedures in order to ensure that the potential usefulness of aerial survey methods is being fully realized,

(b) that research and development of improved methods and equipment for making and interpreting aerial photographs should be energetically pursued, and

(c) that all institutions for higher forestry education should where practicable, offer courses in photogrammetry to their students.

B. Methods of Determining Forest Increment

41. Great attention was given to the need for improved methods of accurately measuring increment in forests of all ages and conditions. Some countries are faced with problems of great difficulty which urgently require solution. It was therefore decided that the International Union of Forest Organizations should be requested to make a special study of methods for determining increment, through the co-operation of its constituent Organizations.

42. *The Congress, recognizing—*

that knowledge of forest increment is essential to forest management for sustained and progressive yield, and that determination of increment entails the solution of problems of great compexity

43. *Recommends—*

that the International Union of Forest Research Organizations be requested to undertake, through its constituent Organizations, an investigation of methods of rapidly ascertaining the increment of forests on a regional basis.

C. Comparative Study of Inventory Methods

44. The Congress reviewed the objectives of the world-wide study of forest inventory methods which had been undertaken by the Forestry and Forest Products Division of F.A.O.

45. Information provided by delegates regarding the methods used in their respective countries served to emphasize the wide differences in inventory procedures which exist. Many of these differences arise from differences in the nature of the forests themselves, others from differences in social and economic conditions and the relative stage of development of forestry practice.

Emphasis was given to the opportunities which a forest inventory offers to assess the kinds and quantities of silvicultural work which may be needed to improve the productivity of the different forest stands. In this connection some discussions arose as to whether future silvicultural treatments should aim at production of trees of high quality or at production of maximum volume of wood. It was informally agreed that "quality" was not the correct word to be used in a discussion conducted in world-wide terms, but that the forests of each country should be managed so as to secure maximum utility under the conditions actually existing in that country. The following recommendation was then adopted :

46. *The Congress recognizes—*

the importance of Forest surveys in developing reliable statistics that are prerequisite to the determination of forest policy, and recognizing the complexity of forest surveys and the wide variety of technique employed, and that a forest survey provides opportunity for formulating prescriptions for silvicultural treatments, endorses the F.A.O. study of the principles underlying the forest surveys of the various nations, and

47. *Recommends—*

(a) Speedy completion of this study,

(b) Enunciation in suitable form by F.A.O. of the principles and techniques that are shown by the study to merit wide application,

(c) co-operation by member nations in assisting F.A.O. to complete the study.

D. Catchment Areas and Water Supplies

48. The subject of protection of catchment areas or drainage basins of streams through the maintenance of adequate protective forest cover was raised.

49. Several delegates described the measures taken in their own countries to maintain protection forests, and others reported virtually complete failure to deal with this essential problem.

50. Attention was drawn to the tendency in some quarters to assume that streams subject to alternative floods and minimum flow can be controlled satisfactorily by dams, storage basins and other engineering works, without re-establishment of forests. The Congress was in complete disagreement with this view.

51. Special attention was drawn to the injurious effects of erosion of slopes and siltation of streams or fresh water fisheries and on hydro-electric power projects and other facilities for the storage or control of water. Lowering of water levels, which often follows denudation of forest cover, has results disastrous to agriculture.

52. The systematic research conducted in certain countries into the protective effects of forests in mountainous areas was discussed. In all cases such research has indicated that forests play a decisive part in stabilizing water regimes and preventing soil erosion.

53. The views of the Section were embodied as follows :—

The Congress emphasizes—

> that failure to protect adequate forest cover in the catchment areas of streams against fire, improper methods of cutting, uncontrolled shifting cultivation, excessive grazing or other destructive forces can have calamitous results with respect to agriculture, fresh water fisheries and industrial developments; warns against the dangers of such neglect; and

recommends—

> that corrective measures should be undertaken wherever necessary.

III. FOREST ECONOMICS INCLUDING FOREST POLICY

A. ECONOMICS AND POLICY OF EXPLOITING VIRGIN FORESTS

54. Besides a report on the exploitation of forests in Finland, which placed particular emphasis on the importance of problems of transportation and of investments considered in relation to the importance of the problems raised, the Congress considered in the first place the exploitation of tropical forests where two situations were referred to.

55. In several countries research is much further advanced than practical exploitation. In those countries exploitation will require inventories, followed by heavy investments by governments within the frame-work of a long-term policy.

56. In some other countries further research is necessary first of all with regard to all species which might be used in order to increase local resources and to permit a continuous flow of supplies to industry, leading to a stabilization of labour conditions. Technological and silvicultural research should also be co-ordinated with this aim in view. Close co-operation between agriculturists and foresters is required, and agricultural methods might even be applied to the reconstitution of the forest. Finally, in certain cases it might be necessary to import food supplies in order to alleviate the pressure exercised on the forest by the requirements of agriculture and pasturage. In many cases this solution would be better economic practice rather than to permit the disappearance of the forest, with all the serious consequences involved.

B. ECONOMICS AND POLICY OF AFFORESTATION

57. Problems of afforestation presented technical, social and economic aspects of which the relative importance varied from country to country. Technical aspects such as protection of the soil and the conservation of water supplies are well recognized and no discussion was raised on these points.

58. Regarding the economic aspects of the problem, the Congress noted the tendency to carry out afforestation by means of planting soft wood and fast growing broad-leaved species in order to satisfy the demand for soft wood sawn timber and wood pulp. With regard to the social aspects the Congress stressed the role of afforestation in keeping the population on the land, stabilizing employment and raising living standards.

59. In conclusion the Congress urged the institution of long term programmes in this field and emphasized the importance which government subsidies and publicity might have in the carrying out of such programmes.

C. Relation of Forestry to Agriculture in Rural Economy

60. The discussions which took place in the Congress subsequent to the presentation of the reports demonstrated the close relationship which exists between agriculture and forestry, which might in certain cases go almost as far as to completely merge the two activities, as in certain regions, where the farmers were nearly all forest owners.

61. This close relationship is indispensable to the maximum utilization of land areas, since it permits a harmonious balance between forestry, pasturage and agricultural production. From the social point of view, moreover, this close co-operation would be evidenced in the stability of labour : land workers would be able to find remunerative employment alternately in agricultural and forestry work including afforestation.

D. Measures Designed to Ensure Sustained Yields

62. With regard to the principle of the sustained yield the Congress listened with much interest to the various definitions contained in the report presented by Prof. Dr. Eino Saari and agreed with him that it was necessary to substitute a more dynamic definition for the present static one, and to replace the term "sustained yield" by the term "progressive yield".

63. The Congress also noted the importance of good fiscal practice in the interests of good silviculture and considered that a reasonable allowance should be made by governments on account of investments necessary for forest improvement until progressive yield is achieved.

E. Employment and Unemployment in Forestry

64. The situation of forest workers and technicians was discussed. It was agreed that continuous production was essential for the stability and the security of these workers.

65. With regard to forestry workers properly so-called, the Congress considered that it was desirable to give them greater stability of employment. This called for better conditions of work, housing, food and social security. Vocational training was also indispensable in order to ensure the maximum of productivity which would in turn lead to an improvement of economic conditions.

F. Conclusions and Recommendations

66. The conclusions and recommendations formulated in regard to Forest Economics including Forest Policy were adopted by the Congress as general recommendations on policy and appear under paragraphs 15 and 16 above.

IV. FOREST UTILIZATION

67. The main issue concerned the economic and social conditions of forest workers and the effect of these on the application of silvicultural methods. Tied in with this was a discussion on the need for increasing the efficiency of forest labour and extraction methods both in tropical and temperate zones. This might be attained through the application of time and tool studies and the rationalization and mechanization of exploitation methods, which have assumed increasing importance in many countries particularly during the last decade, owing to the growing difficulty of securing forest labour. Training schools for the workers were emphasized as an efficient method of obtaining better results.

68. *Recognizing—*

that there exists in many countries a necessity for improving working and living conditions in forest work and forest industries, and that in many countries the benefits to be derived by the workers are irrevocably tied up with the financial returns of the industries concerned ;

The Congress recommends—

that, in considering matters pertaining to forest exploitation, both social and economic implications be borne in mind.

69. *Recognizing—*

that forest conservation and wood utilization are dominant factors in the national economy of many countries, and that there is urgent need for the improvement of working procedures,

The Congress recommends—

that schools be instituted in as many countries as necessary for the specialized training of forest labour.

70. *Recognizing—*

the importance of improved labour efficiency

in harvesting forestry products, and the need for extended time studies related to both hand tools and mechanized equipment.

The Congress recommends—

that a permanent sub-committee of the Standing Advisory Committee for Forestry and Forest Products of F.A.O., composed of experts from various countries, be established for the purpose of co-ordinating time studies in forest work and all other methods of study related to the various types of hand tools and mechanical harvesting devices as used in forest operations throughout the world.

71. At the same time, the Congress

urges—

that F.A.O. continue its activities in gathering and distributing information regarding logging equipment and techniques, as a means of implementing the preceding recommendation.

72. *Recognizing*—

that tropical forestry is faced by special problems,

The Congress recommends—

that a special international conference of those interested and engaged in tropical forestry be called by F.A.O. as soon as convenient.

V. FOREST INDUSTRIES

A. Inter-relationship between Forestry and Industry

73. The Congress,

recognizes—

the inter-relationship between forestry and industry and emphasizes the fact that a two-way approach to the question is necessary in order to keep foresters in touch with the trends of industry and industry in touch with the trends of silviculture in order to fill the demand arising from growing human needs,

that it is important to increase the quantity and to improve the quality of forest stands, according to the needs and trends of industry in conformity with the principles of the sustained and progressive yield,

74. *recommends*—

that a programme of scientific, technical and economic research on wood should be carried out in all countries by means of close co-operation between the interested parties for the purpose of co-ordinating forest production and wood-using industries,

that silviculturists should endeavour to increase the quantity and to improve the quality of forest products, according to the needs and trends of industry, on the basis of continuous production, and in conformity with sound silvicultural practice,

that industry should endeavour to utilize forest products in the best way possible, taking into consideration the trend towards a decrease in fuel wood consumption,

that industry should be invited to develop further the utilization of wood from non-coniferous species, wood in small dimensions and, if possible, bark.

B. Wood Waste in the Forest and Industry

75. The Congress,

recognizes—

that the problem of the utilization of wood waste remains one of the main pre-occupation of forest economy,

that from the industrial aspect efforts are also needed, not only to improve existing practices, but also to create new ones in line with technical progress,

that co-ordination or integration of wood-using industries is important in order to reduce wood waste and to ensure that the various wood-using industries utilize forest resources to the best advantage, and

76.

that scientific research on an international basis, aiming at utilization of wood waste, should be continued and increased,

that, in order to assist technical research, regional organization of basic scientific research is desirable, and

77. *recommends*—

the encouragement of co-ordination and even of integration of the various wood-using industries,

that efforts should be made not only to expand outlets for wood waste but also to create new ones in conformity with technical and industrial progress,

that special attention should be given to the grading of timber in order to ensure to each product its appropriate use,

78.

that scientific research aiming at the utilization of wood waste should be continued and increased from the physical, chemical, mechanical and biological point of view,

that, in order to attain these aims, the laboratories concerned are invited to co-ordinate scientific and technical research and F.A.O. should collect and disseminate information on the results achieved in various countries.

C. Wood Chemical Industries

79. The Congress,

recognizes—

the importance of wood chemical industries in regard to rational utilization of forest resources,

the necessity of research on wood chemistry, pulp and paper,

the need for developing techniques for producing dissolving pulps of uniform quality,

the importance of giving more attention to woods of broad-leaved species, including tropical woods, for the manufacture of pulp and paper,

that semi-chemical pulping processes afford an opportunity for overall conservation of pulpwood resources because of the greater yields obtained and of the reduced wastage of wood constituents, and

80. *recommends*—

that more extensive use should be made of the woods of broad-leaved species, including tropical woods, for the manufacture of paper pulp in order to conserve softwoods for other purposes,

that semi-chemical pulping should be encouraged in order to ensure an overall conservation of pulpwood resources.

D. Preservation of Wood

81. The Congress,

recognizes—

the importance of wood preservation in reducing wastage caused by deterioration during storage and use, thus also making increased quantities of timber available,

that woods which are otherwise difficult to impregnate may be satisfactorily treated by the application of *high* pressure, and

the importance of boric acid and borax in treating sap-wood of broad-leaved species in order to prevent attack by Lyctus, and

82.

the importance of structural design and the fire-proofing of timber in reducing the risks of fire.

E. Pre-fabricated Wooden Houses

83. The Congress,

recognizes—

the importance of pre-fabricated wooden houses in meeting the present housing emergency by providing a rapid means of erection and in circumventing the shortage of skilled labour which would be necessary for the construction of houses according to more orthodox methods,

that the optimistic views previously held with regard to pre-fabricated houses have not been substantiated,

that a greater degree of individuality is desirable,

that the various component parts be standardized,

that even the larger parts be assembled in factories and be so designed that they can be transported without sustaining damage,

that the development of pre-fabricated wooden houses in different countries varies

with climate, traditions and customs, individuality of the people, density of population within a given area, and availability of skilled labour,

that much depends upon technical developments within the industry in order to lower the high construction and transport costs of pre-fabricated houses, and

84. *Recommends*—

that houses must have more individuality in character,

that various component parts be standardized to a high degree.

F. THE TAPPING OF PINES FOR ROSIN AND TURPENTINE

85. The Congress,

recognizes—

that the production of resin can be stimulated by chemical treatment, and urges that research along these lines be continued,

86.

that it is also important to pursue research on the influence of tapping upon the biology and properties of pinewood.

COMPILATION OF A MULTILINGUAL DICTIONARY

On the basis of a draft resolution submitted by a Working group set up by the General Committee under the Chairmanship of Mr. Leloup.

The Congress,

recognizing—

the difficulties frequently encountered in translating technical forestry literature from one language to another because of the lack of an authoritative international forestry dictionary ;

considering—

that these difficulties constitute a serious hindrance to the dissemination of technical information ;

believing—

that such a dictionary should include not only a balanced selection of terms from all branches of forestry but also definitions of forestry terms and particularly those which are subject to different interpretations,

recommends—

that a multilingual dictionary thus compiled should be prepared in the English, French, German, Italian, Russian, Spanish and Swedish languages, and that the United Nations with the help of F.A.O. and I.U.F.R.O. should give immediate consideration to this project, endeavour to arrange for international adoption of the necessary definitions, and find ways and means for the preparation and publication of a multilingual forestry dictionary.

PRESERVATION OF WILD-LIFE IN INDIAN FORESTS—A PLEA FOR NATIONAL PARKS*

BY DR. M. L. ROONWAL, M.SC., PH.D. (CANTAB.), F.N.I., MAJOR,
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I. INTRODUCTION

The forest wealth of India comprises three chief items. These are: first, the plant wealth; secondly, the animal wealth; and lastly, the rôle which forests play in regulating climate, enhancing rainfall and conserving soil. Unfortunately for forest conservation, emphasis has been laid on the destructive aspect of animals, e.g., on insect pests of forests and forest products. Too little attention has been paid in India to wild-life (especially birds and mammals) which play a not negligible rôle in the economy of forest conservation, not to speak of a variety of other purposes that wild-life serves. Birds play an important rôle in the control of insect numbers and the pollination of forest flowers, and, besides, can be a source of perpetual joy to the observant forest officer and members of the public who visit forests. Rodents, such as rats, bandicoots and rabbits, can be highly destructive to forest plantations, but also serve to loosen up the soil by means of their burrows. Yet, very little scientific information is available on these matters, although forest officers have unlimited opportunities to observe and to collect both birds and mammals. Some of our species, such as the rhinoceros and the lion, are practically on the verge of extinction through overhunting, and hardly a few hundred heads are left in isolated areas.

One of the best ways of serving the ends of wild-life conservation for the benefit of man is by the establishment of National Parks which should be both extensive and numerous if they are to serve their purpose. National Parks are national assets. This simple dictum has to be realized before national enthusiasm can be roused to demand national parks. Every major civilized country outside those in southern Asia has a large and growing number of such preserves. The U.S.A. has perhaps outstripped all other countries in the number and variety of its national parks, while the parks of Africa are famous all the world over for abundance of big game.

The value of national parks is five-fold (Chart I). First, they serve to preserve areas of exceptional scenic beauty from being spoiled by exploitation. Here the poor and the rich all may repair, have a quiet holiday and enjoy the natural beauties of our country. Secondly, they serve to preserve the important elements of our fauna and flora for posterity. Here the wild animals may live in peace, and here too we can watch them in their natural habitat. Thirdly, they serve to provide the scientist with excellent field laboratories for studying at leisure the natural habits of wild animals, without the gnawing fear in his heart that what he is studying is not natural, or that the objects of his study might soon disappear from the land, never to return again. Fourthly, they serve to preserve those species of animals and plants which are on the verge of extinction. We give them, so to speak, a sporting chance to recover their lost potentiality and to increase in number. In some species the speed of extinction may have gone so far and the species-vigour reduced to such desperately low proportions that the species can perhaps no more survive. Others, however, which have not yet reached too close to the bottom of this steep decline, recover by protection and are normal again in course of time. And fifthly, national parks are economic assets of the nation. They serve to increase the actual, and much more so the potential, animal—and plant-wealth of the country. Much of this wealth means more food. Take the ducks and geese that leave every winter their northern homes in Siberia and migrate down south to India in millions. To the ignorant their welfare is not his concern, and he only thinks of shooting them by the thousand. They would come next winter in any case, he argues; so why bother. But that is the road to disaster. The numbers of the migrants are

* For the purpose of the present article, India, Pakistan, Ceylon, Burma and Nepal have been treated together as a single geographical unit. No political significance need be attached to this unity.

not inexhaustible, and the more the number of dead in this country, the fewer the number of those that will return next year. In short, we must provide them with sanctuaries, like lakes and large tanks, along the migration routes, so that the birds may live undisturbed at least in those areas. The U.S.A. has made a great success of this plan, and has provided hundreds of such sanctuaries, both big and small. Let us emulate this wise example.

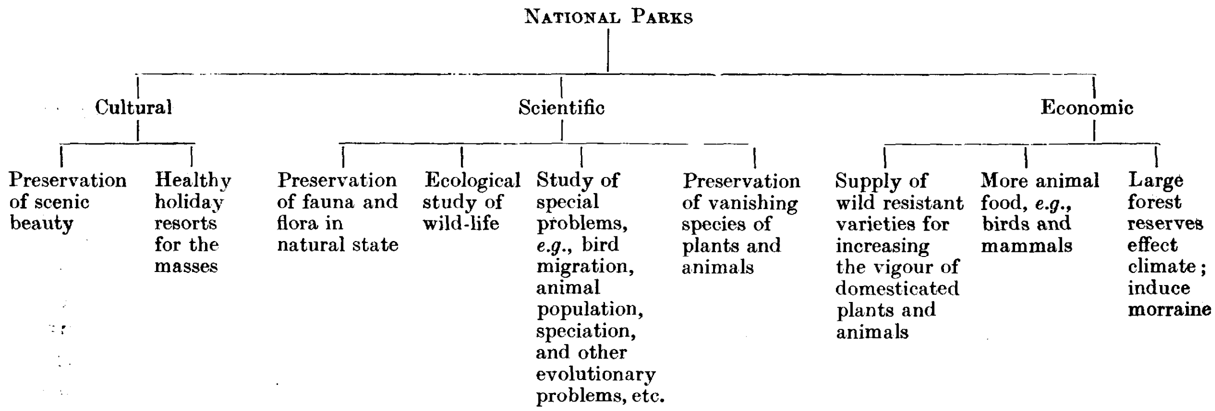

CHART I—The utility of National Parks to the nation.

II. BIOLOGICAL ASPECTS OF NATIONAL PARKS

A variety of multi-purposes Ecological Laboratories can be established in the national parks for the study of their fauna and flora in the natural state. Here the specialist can go and also the young students who need training. These laboratories would provide excellent training ground for future ecologists and field scientists.

The ecological laboratories should have special sections for the study of particular problems like speciation and other evolutionary problems in nature, bird migration and animal populations. The importance of these studies both to national welfare as well as for the advancement of fundamental science has in recent years been emphasized by the writer (Roonwal 1940, 1945)—an emphasis that has received support from a variety of sources, *e.g*, from Husain (1946, pp. 16–17 ; 22), Sewell (1946, pp. 10–11 ; and 46) and *Nature** (1946). Thus, Husain wrote (pp. 10–11): "Investigations carried out in America indicate the importance of wild-life. It has been shown that where marshes have been reclaimed for cultivation, the benefit gained has not compensated for the loss sustained through the destruction of wild fowl. We have approximately 200,000 square miles of forests. Can they not be stocked with eatable birds ? There is immediate need for a thorough survey and population study of the wild-life of India as a preliminary to a national planning of game improvement. "Hitherto we can study these problems only in zoological gardens and hot houses where conditions are far from natural. Migration Observatories and Animal Population Stations ought to form an integral part of the programme for the creation and development of national parks.

III. THE VANISHING SPECIES

Nearly a dozen species of our animals are vanishing fast and are in immediate danger of extinction. The only remedy to prevent this irreparable loss to the national fauna is the establishment of national parks in those areas where the vanishing species have survived and need protection. Remember that only a centuary ago many of these animals, *e.g.* the lion, the rhinoceros, etc., were to be found in vast areas of the country (pl. 1). Below is given a list of the vanishing species, together with the most suitable areas [written within square brackets] for the establishment of national parks for their preservation.

* Review of Roonwal's (1945) ariticle on Animal Population Problems.—*Nature*, London, vol. 157, pp. 156–157 (1946).

(*a*) MAMMALS

1. All the 3 Indian species of rhinoceroses, *viz*, the Great One-horned Rhinoceros (*Rhinoceros unicornis* L.), the Smaller One-horned Rhinoceros (*Rhinoceros sondaicus* Cuv.) and the Sumatran Two-horned Rhinoceros (*Rhinoceros sumatrenis* Cuv.). [Bengal (?), Assam, Nepal, Burma].
2. The Indian Wild Ass or Ghor-Khar (*Equus onager indicus* Bly.). [Baluchistan, Western Sind and Cutch].
3. The Sind Ibex or Wild Goat (*Capra hircus blythi* Hume). [Barren hills of Baluchistan and Western Sind, chiefly the Kirthar Range].
4. The Musk Deer (*Moschus moschiferous* L.). [The Himalayas].
5. The Thamin or Brow-Antlered Deer (*Rucervus thamin* Thos.). [Burma, Malaya].
6. The Wild Buffalo (*Bubalus bubalis* L.). [Grass jungle of the Terai in Bengal and Assam ; also Orissa (?)]. Once occurred in Central Provinces, but probably now extinct there.
7. The Indian Pangolin (*Manis pentadactyla* L.). Widespread in India ; but vanishing in Assam. [Assam].
8. The Caracal (*Caracal caracal* Müll). [Western and Central India].
9. The Cheeta or Hunting Leopard (*Acinonyx jubatus venaticus* Gr.). Probably now extinct in India, though 50 years ago it occurred all over North India.
10. The Indian Lion (*Panthera leo persica* Mey.). Formerly occurred all over North India. [Now reduced to less than 200 heads, confined to a few miles in the Gir forest in Kathiawar].

(*b*) BIRDS

1. The Pink-headed Duck (*Rhodonessa caryophyllacea* Lath.). [Assam].
2. The White-winged Wood Duck (*Asarcornis scutulatus* Müll.). [Assam].

It will be noticed that most of the areas required for the preservation of the vanishing species lie in Northern India. We have to-day about half a dozen small parks in India, but they are neither extensive enough nor numerous enough. They also need to be more effectively publicised. A good example of what protection can do is provided by the Indian lion. Reduced to less than 20 heads in 1913, protection in its last surviving place (the Gir forest) has now increased their number to about 200.

IV. CONCLUSIONS

It should be clear by now that without a discrete organization the efficient protection of wild-life, whether through the agency of National Parks or by other means, is hardly possible. The burden of wild-life protection to-day rests on the already well loaded shoulders of the provincial forest officers. To co-ordinate and plan the work, however, there is need of a central authority which would take a broad all-India view of protection-problems and lay down general policies which the provincial forest officers can follow.

There would appear to be two prime needs of the moment. First, the establishment of a Board of National Parks (Chart 2). Secondly, a machinery for popular education on wild-life protection, by such means as the production of popular, attractively illustrated pamphlets for the use of school children and of the lay public.

BOARD OF NATIONAL PARKS IN INDIA

President

Secretary	Scientific Division, with various Field Laboratories and Stations	Council	Advisory Committee

CHART 2—Proposed organization for National Parks.

In both these activities the existing organization of the Forest Research Institute, Dehra Dūn, especially of its biological branches, can and perhaps should play a dominant rôle. The needs of economy and efficiency demand that an entirely separate organization need not be created. For instance, the President of the Forest Research Institute might well become the

ex-officio President of the Board of National Parks. The proposed field laboratories would also serve the Forest Research Institute. In fact the two organizations must work in the closest possible *liason*. In addition to the President, the Board will consist of a Secretary, a council of experts consisting of perhaps 20 members (mostly scientists), and an advisory committee of 40 members consisting of both scientists and those representing various public interests.

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EXPLANATION OF PLATE I

Animals like these will soon disappear from India, if no immediate and rigid protection is given.

FIG. 1.—The Indian Lion, *Panthera leo persica* Mey.

FIG. 2.—India, showing the part (about 1800) and present distribution of the lion. (From various sources). The extreme shrinkage of range is due to want of protection.

FIG. 3.—The smaller One-horned Rhinoceros, *Rhinoceros sondaicus* Cuv.

FIG. 4.—The Sumatran Two-horned Rhinoceros, *Rhinoceros sumatrensis* Cuv.

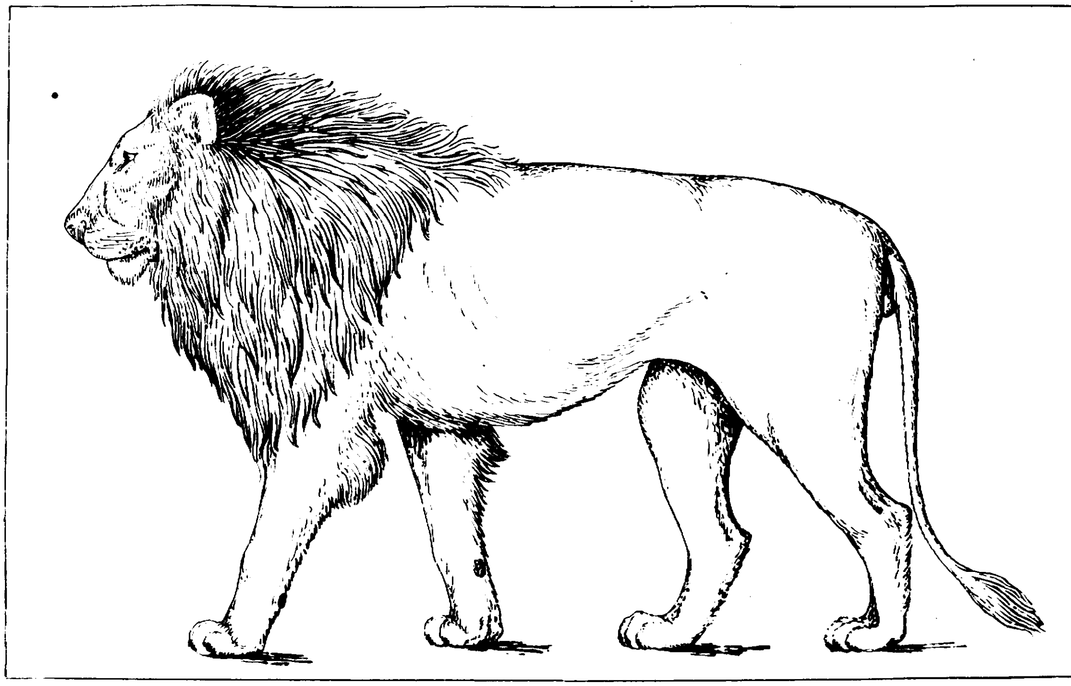

FIG. 1

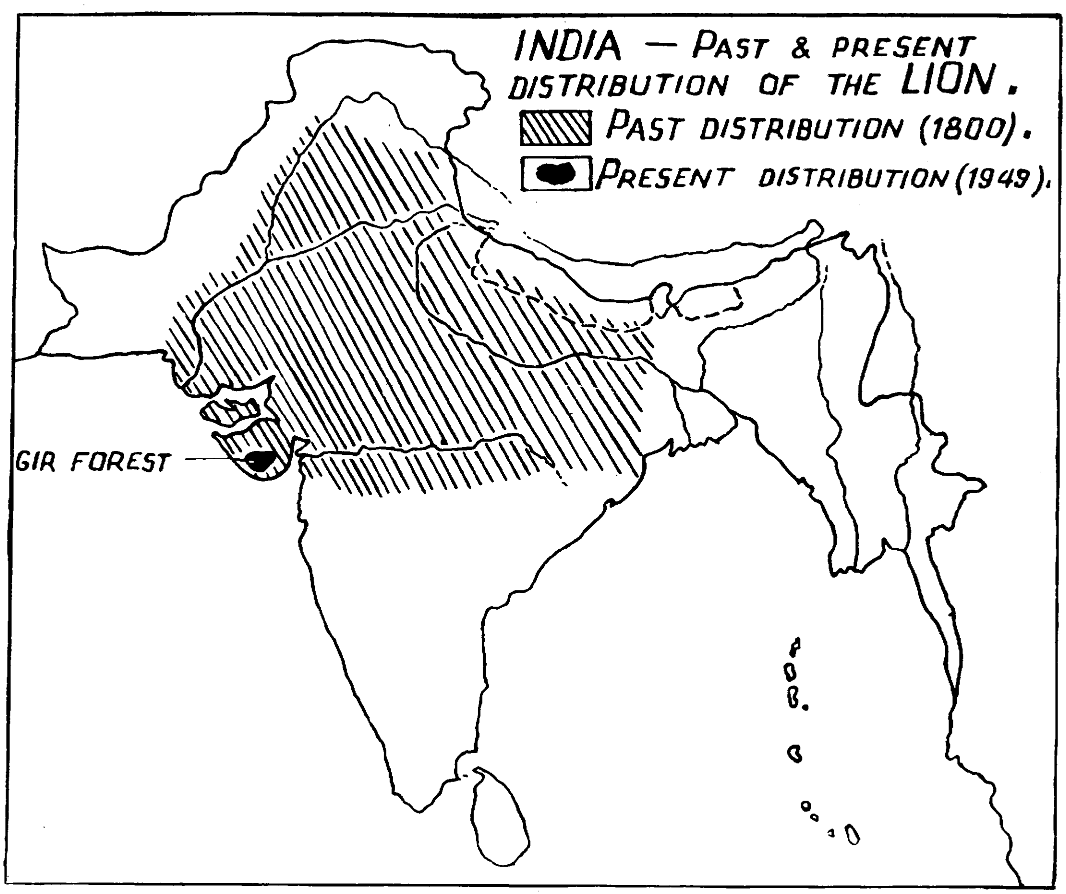
INDIA — PAST & PRESENT DISTRIBUTION OF THE LION.
PAST DISTRIBUTION (1800).
PRESENT DISTRIBUTION (1949).
GIR FOREST

FIG. 2

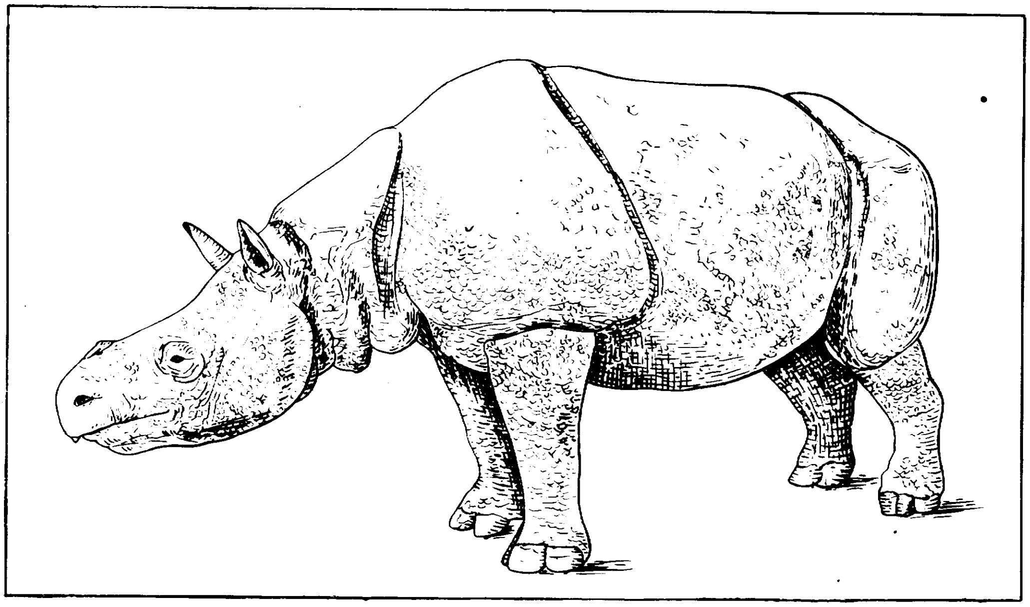

FIG. 3

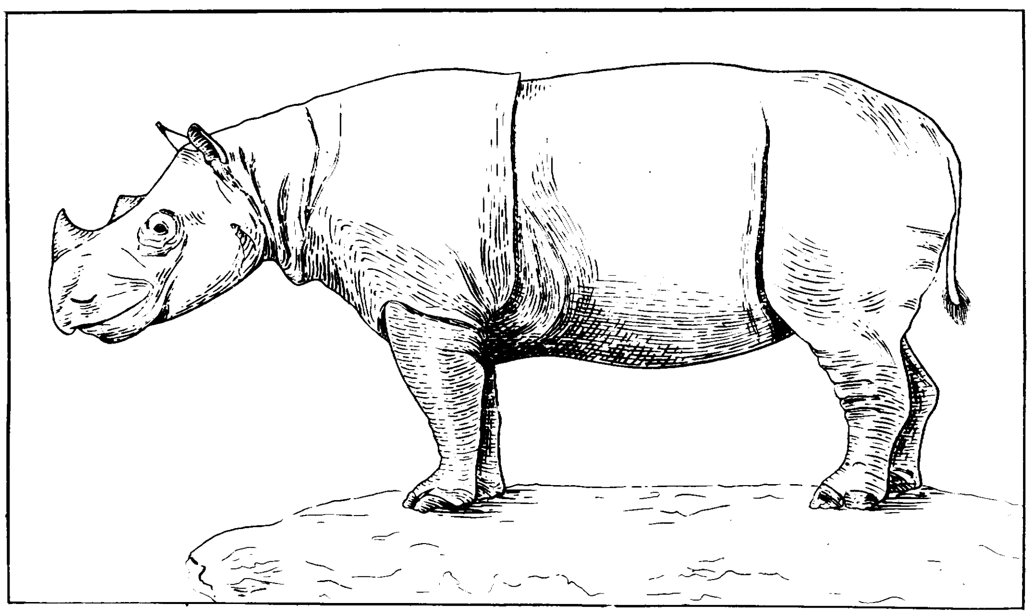

FIG. 4

A BRIEF HISTORICAL SKETCH OF THE INTRODUCTION OF STATISTICAL METHODS IN INDIAN SILVICULTURAL EXPERIMENTS

BY DR. K. R. NAIR,

(Statistician, Forest Research Institute, Dehra Dun)

The publication of the Experimental Manual in 1931 by Mr. Champion as a result of the recommendations of the Silvicultural Conference of 1929 marked the starting point in standardizing methods of experimental research in Indian forestry. The importance of statistical analysis received recognition at the hands of the author by the inclusion of a chapter on 'statistical methods' in this Manual.

The statistical principles involved in Experiment Design were developed by R. A. Fisher at Rothamsted with special reference to agricultural research during the preceding decade. Until the setting up of the Imperial Council of Agricultural Research in 1929 and its insistence that all field experiments in agriculture under schemes financed by the Council should be laid out in conformity with the principles expounded by Fisher, comparatively little was known about these methods even to the agricultural research workers in India.

Forestry research naturally lagged behind. Whereas most agricultural experiments gave results in the course of a single season, many silvicultural experiments took years and even decades to produce results of scientific value. It was difficult to incorporate the new principles of experiment design in investigations already started. Consequently the adoption of the new technique to silvicultural experiments was a slow process.

Under the heading "Methods of Experimental Research" the fourth Silvicultural Conference held at Dehra Dun in 1934 discussed methods of statistical analysis of data collected in the course of silvicultural experiments. Mr. Champion (Silviculturist, F.R.I.) reported that he considered that much further study was needed of the statistical aspects of working with small samples, and that he was in correspondence with statistical authorities on the point. Mr. Laurie (Madras) pointed out that abnormal distribution series were frequently encountered in silvicultural research data. Mr. Chaturvedi (U.P.) referred to the solution sometimes applicable to the difficulty in finding initially comparable plots for co-operative investigations.

Definite progress was made in the F.R.I. between 1934 and 1939 in the study of the statistical methods of design and analysis of experiments. Two statistical assistant silviculturists (M. A. Kakazai and Bakshi Sant Ram) were sent in quick succession in 1936–37 to the Indian Statistical Institute, Calcutta for special training in these methods under the guidance of Professor P. C. Mahalanobis. This training bore immediate fruit in as much as a clear exposition of the methods was presented to the fifth Silvicultural Conference in 1939 by Mr. Sant Ram. It was resolved by the Conference that chapter XVII on *Statistical Methods* in the Experimental Manual should be rewritten to include recent developments and improvements in methods of statistical analysis, combining with it the section on experimental design and lay-outs, on the lines indicated by Mr. Sant Ram in his paper under this item.

Mr. Laurie, the Central Silviculturist, in making an emphatic plea for the use of modern statistical methods in experimental research prefaced his speech in a picturesque way as follows :—

> "The average Divisional Forest Officer, if he is not too hard worked as is so often the case, is keen and interested in doing small silvicultural experiments. He lays out a couple of plots, treating one plot one way and the other in a different way. He takes measurements and gets a result. The first treatment has given better average height growth then the second. Then along comes the silviculturist and says "yes,—that is all very pretty—but it is not significant" whereupon the Divisional Forest Officer very naturally feels like knocking him on the head and dropping him down the nearest well.
>
> In the past a very large amount of that type of experimental work was done. Mr. Champion can vouch for it, and I have seen

a good deal of it myself. *The length and breadth of India are littered with the remains of abortive experiments*, though a great improvement was brought about when the Experimental Manual first came to be used*".

In 1940 at the invitation of the President, F.R.I. & Colleges, Professor Mahalanobis visited the Institute and gave advice on various statistical problems referred to him by officers of the Silviculture Branch and other branches of the Institute.

At the Sixth Silvicultural Conference, 1945, Dr. Griffith, the Central Silviculturist, pointed out that it has been found impossible to deal effectively with statistics and statistical problems in the experimental manual as the subject had expanded and been developed enormously since Champion wrote the original section which was published in 1931. He therefore suggested that a separate "Statistical Manual" whould be written dealing with the statistical principles of design and analysis of forest experiments.

The Conference agreed to his proposal. In 1947, Dr. Griffith and Mr. Sant Ram jointly published the Statistical Manual as Vol. 2 of the revised "Silviculture Research Code". This volume is in three parts. Part I gives general principles and includes only as much mathematics as is found absolutely essential, Part II describes the design of forest experiments and Part III consists of a number of typical examples of the working out of typical forest experimental data.

Although this volume will be of immense value in silvicultural experiments, it was felt that the subject of experiment design and analysis of data had been expanding at such a rapid pace as to need the full time service of a specialist. In the post-war reorganization scheme of the F.R.I., provision was therefore made for the creation of a Statistical Branch headed by an expert statistician. This Branch was brought into existence on 1st August 1947 and has taken over from the Central Silviculturist, work connected with experiment design and analysis of data of silvicultural experiments. This Branch caters for the other branches of the F.R.I. in planning of experiments and analysis of data according to modern statistical principles.

In response to enquiries from some provinces and states, the Statistician gave a refresher course to Provincial Silviculturists in November–December 1948 on the statistical principles of design and analysis of experiments. It has been proposed to conduct this course every year for the benefit of provincial officers in charge of experimental research.

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* See p. 96 of the Proceedings of the Fifth Silvicultural Conference 1939.

EVERGREEN, MONTANE FORESTS OF THE WESTERN GHATS OF HASSAN DISTRICT, MYSORE STATE—(*contd.*)

A Contribution to the Ecology, Plant Geography and Silviculture of the Western Ghat Forests of Mysore

BY KRISHNASWAMY KADAMBI

(*Assistant Silviculturist, Forest Research Insititute, New Forest, Dehra Dun*)

SECTION 7.—*Forest type*

41. The type of forest under consideration has been given different names by different authors*. A. F. W. Schimper has called this "*Tropical Rain-forest*". Chipp has placed it under "*Rain Forest*". R. S. Troup has given it the name "*Tropical Evergreen or Rain Forest*". H. G. Champion has named the type "*Southern Tropical Wet Evergreen*". J. Burtt Davy has suggested the name—"*Tropical Lowland Evergreen Rain-forest*".

42. I have proposed to call them* "Evergreen Ghat Rain-forest". This word "Ghat" has local significance because the forest exhibits certain pecularities which have resulted from the œcological conditions reigning at the crest of the Ghat, as opposed to the evergreen forest in the interior of the Mysore tableland which covers the Bababudan, Kalhathagiri and Mulliangiri group of hills which differ notably from the evergreen forest at the crest of the Ghat in the composition of the tree growth.

43. The Working Plan Manual of Mysore† in laying down instructions for the recognition of forest types in Mysore has described the evergreen type of forests in the following manner :—

"It is characterized by an evergreen forest canopy, often filling all the space from the tops of trees to the forest floor, the presence of the most luxuriant vegetation which nature has produced in Mysore with very tall, well formed trees standing a hundred to a hundred and fifty feet high in its top canopy layer, huge, often cylindrical tree boles, the presence of canes, other characteristic palms and reed bamboos".

"*Other distinguishing characteristics*"

"*Rainfall* :—150 to 350 inches or more".

"*Soil* :—Lateritic, with a heavy layer of fallen leaves and humus".

"*Sub-soil* :—Laterite, vescicular, porous and characteristically mottled in colour; iron content high".

"*Negative characters*—Absence of the bamboos *Bambusa arundinacea* and *Dendrocalamus strictus*, Disastrous fires are usually unknown in the type as the forest is not inflammable".

"*Important species.—Pœciloneuron indicum*‡ (*balagi*) *Dipterocarpus indicus* (*dhuma*), *Mesua ferrea* (*nagasampige*) *Hopea parviflora* (*kiralbhogi*), *Calophyllum elatum* (*surahonne*), *Palaquium ellipticum* (*hadasale*) and others".

"*Characteristic palms*.—Climbing palms (canes) and *Pinanga dicksonni* (*janjarige*)".

"*Growth variations and zones*.—

(1) *Ghat-crest zone*.—Facing directly the monsoon winds from the Arabian sea".

(2) *Ghat zone proper*.—Occupying the leeward slopes and valleys at the head of the ghats and scoured by perennial streams".

(3) "*The fore-hills zone*".

(1) "*Ghat-crest zone*".—

"*General characters*.—The area is generally fully wooded except where sheet-rock intervenes or recent land-slips have occured. Rainfall is usually maximum here, consequently also the humidity. Festoons of hanging reindeer-moss, epiphytic musci and bark algæ are therefore most prominent. Trees standing right at the head of the ghat overlooking the Arabian sea exhibit sometimes fan-shaped

* "The Evergreen Ghat Rain-forest; Agumbe Kilandur Zone" Indian Forester, April 1941, page 3, by Krishnaswamy Kadambi.

† Working Plan Manual, Mysore; Appendix V, "Instructions for the determination of forest types and quality classes",—by Krishnaswamy Kadambi.

‡ This species is absent from Hassan Ghats.

crowns, owing to wind effect. On descending the preciptous slopes facing the Arabian sea, the temperature rises rapidly".

"*Principal species.—Pœciloneuron indicum* and *Mesua ferrea*; underwood *Lansium anamalayanum*".

(2) "*Ghat-zone proper*".—

"*General characters.*—Area usually fully wooded except the hill tops which are occasionally* bare. The wooded valleys contain the most luxuriant kind of vegetation which nature has produced in Mysore. Tall, cylindrical boles 100 feet or more high and full roundheaded crowns characterize the trees in the top layers of the canopy".

"*Principal species.—Pœciloneuron indicum, Dipterocarpus indicus* and *Palaquium ellipticum*; underwood *Humboldtia brunonis* and *Unona pannosa*."

"(3) *The Fore-hills zone.*—This does not represent probably the climax of the evergreen forest formation, and it occupies a zone about 3 miles away from the head of the ghat. The hill-tops of this zone are generally bare and grassy, and the wooded portion is confined to the valleys tenanted by perennial streams."

"*Principal species.—Hopea wightiana, Hopea parviflora, Artocarpus hirsuta, Holigarna arnottiana' Holigarna grahmii, Canarium strictum, Myristica malabarica*, etc."

"Edaphic variants on the evergreen type are pretty frequent, the following being among he common ones" :—

Principal growth	*Edaphic conditions*
"(*a*) (1) *Elæocarpus tuberculatus association.*—	"Borders of perennial streams full of percolating water but well drained."
"(2) *Lophopetalum wightianum* association."	"Borders of perennial streams full of percolating water but well drained."
"(3) *Veteria indica-Elæocarpus tuberculatus* association.	do.
"(4) *Vateria indica* association."	do.
"(5) *Calophyllum wightianum* association."	do.
"(6) *Pœciloneuron indicum* association."	do.
"(7) *Mastixia arborea* association."	do.

"*Nature of growth*"	"*Edaphic conditions*"
"(*b*) Grassy blanks with sprinkled tree species able to withstand poor drainage, not necessarily evergreen, often exhibiting xeropphytic characters.—*Careya arborea, Butea frondosa, Zizyphus sp.*" "*Gardenia sp., Bucanania latifolia, Randia uliginosa, Randia dumetorum, Dillenia indica*, the shrub *Wendlandia notoniana*, the palm *Phœnix humilis* and the bracken *Pteris aquilina*."	"Water-logged and incompletely drained localities; soil very shallow, subsoil impervious owing to laterite or other hard rock being too close to the surface."

SECTION 8.—*Habitat distinctions in the evergreen forest*

I. GENERAL

44. An examination of the forest formation which clothes the Western Ghats of Hassan district reveals striking differences in character, both vegetative and floristic, in different localities. These differences are due :—

(1) to the altitude, which has its basis partly in temperature difference ;

(2) to local differences in the edaphic conditions due to shallow soil, depth of underlying rock, drainage or occasionally dissected erosion topography which causes differences in atmospheric humidity and wind action.

and (3) to climatic difference between the western or windward, and the eastern or leeward, slopes of the range, which has its basis in differences in rainfall (precipitation) and the number of hours of sunshine and variations in atmospheric humidity.

45. The marked climatic difference between the western and eastern slopes due to the prevailing direction of the wind and the drying effect of the hot afternoon sun operates in a manner and direction which obscures any influence which the direction of the slope in relation to isolation might have in differentiating the condition of the vegetation on the western and eastern slopes. Similarly, the difference in the conditions of atmospheric

* These are generally always bare and rocky in the Hassan Ghats.

PHOTO 3

The narrow valley-bottoms and ravines tenanted by perennial streams are the most hygrophilous habitats of the rain forest. They are protected from wind and the western sun.

PHOTO 4

The floor of the forest is covered with flowering plants and natural regeneration of the tree species or terrestrial ferns. The fern in the picture is Angiopteris evecta.

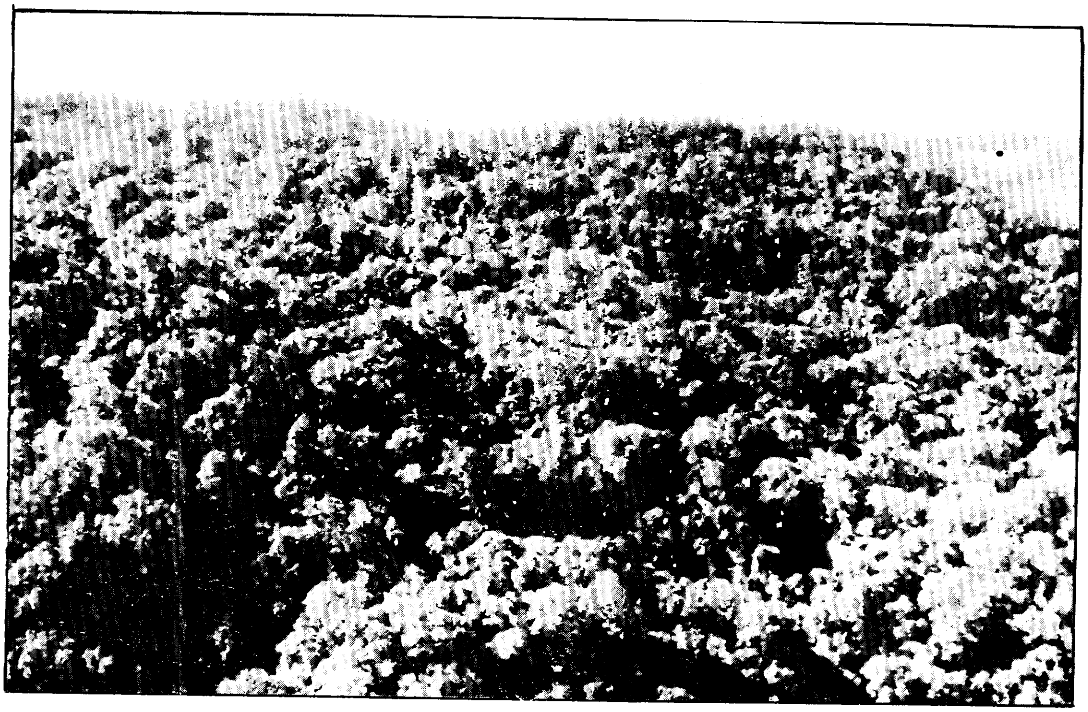


PHOTO 5

↑ When the top canopy of the valley forest is seen from any opposite elevated point or an adjecent slope is presents sometimes great irregularity of surface....

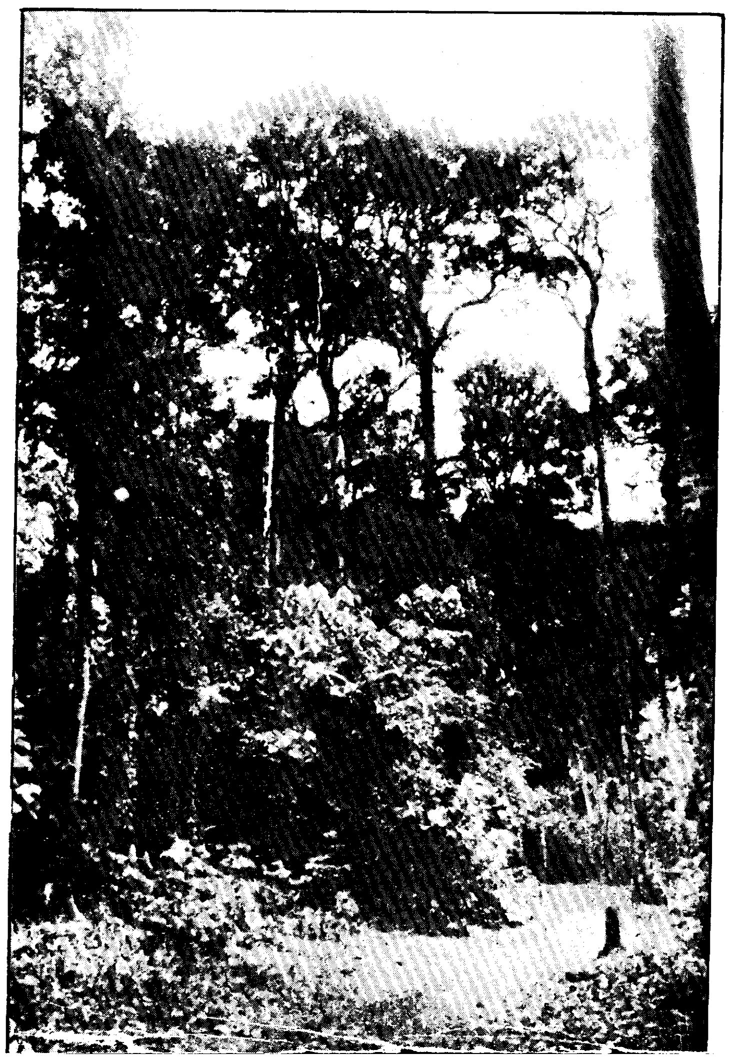
Photo. Author.

PHOTO 6

→

The top storey of the forest is composed of trees which generally raise their crowns well over the rest of the forest......... Among them are *Dipterocarpus indicus*... The picture shows a group of giant dipterocarps which stand about 150 feet high with girths 14 feet and over.

Photo. Author.



humidity between the bottoms of narrow, deep valleys and the summits of ridges (and hill-tops) obscures to some extent the influence which differences in the amount of soil moisture create in these habitats owing to the relatively hot, dry, long summer. In view, however, of the very unequal distribution of rainfall during the year, I feel confident in stating that the fluctuating amount of soil moisture is a very important factor governing the forest type and distribution of vegetation. On hill-tops and ridges, especially on western hangs, the depression of soil moisture content is sufficient to defoliate, if not kill, the hygrophilous and many mesophilons shrubs and herbaceous plants, particularly because the long rainless period is one of high percentage of isolation, high temperatures and low humidity.

46. The differences in temperature which exist between an elevation of 500 feet and 3,000 feet is of considerable significance to the vegetation as the increase of temperature signifies an increase of evaporation and consequent decrease of moisture available for plant life. The difference in temperature is of considerable significance since the rainfall remains the same. The smaller difference between the 3,000 feet level and the summit of the highest peak—Jenukallu (4,533 feet) is of no such importance, and does not seem to be responsible for limiting the vertical distribution of the tree species.

47. During the hot days of summer the difference in temperature on the western, windward slopes with varying altitude tends to greatly influence the transpiration and growth owing to the relatively dry atmospheric conditions of this season ; and at higher altitudes, on ridges, where the wind ascending from the sea against the western wall of the ghats races off unimpeded across the tableland with tremendous velocity, the dessicating effect of wind resulting from the greatly increased transpiration is very high. In the rainy season, on the other hand, the temperature conditions on the windward slopė between the altitudes mentioned are made more uniform then on the leeward slope by the fact that much of the dynamic cooling of the air driven up from the nearby west coast goes into the condensation of moisture. The differences of summer temperature between the higher and lower altitudes account for the gradually increasing deciduousness of the growth from the crest of the ghat downward, but this difference is, to a certain extent, offset by the deep, narrow valleys tenanted by perennial streams, where the summer heat causes a moist fog to ascend from the bottom of the valley which increases the humidity of the air and blunts the drying effect of the higher temperature at lower altitudes. The greatly undulating country in which the high western wall ends sometimes abruptly and at others less so, or the leeward slopes which are sometimes formed on the eastern side of the crest of the ghat, enjoy generally a higher rainfall just beyond the main ridge than other places either lower down on the windward or leeward side or those situated even at a higher level but in the interior of the tableland some distance away from the crest of the ghat.

48. The sets of factors indicated do not operate independently, neither do the different habitats fail to merge into one another in the character of their vegetation. Narrow and deep valleys with a western aspect and open on the windward side resemble in many respects relatively shallow and broad valleys with either an eastern aspect or those protected from the western wind ; ridges and peaks on the leeward side with an eastern aspect are clothed with tree growth up to a much higher altitude than on the western windward side, and ridges protected from western wind and sun are often fully covered with forest much like valleys on windward slopes with western aspect.

49. The valley bottoms and ravines tenanted by perennial streams (Photo 3) are the most hygrophilous habitats in the rain-forest ; particularly near their bottoms which are protected from wind and western (afternoon) sun, they show a wealth and luxuriance which rival any that nature has produced elsewhere in the tropics.

50. The following sections embrace a brief descriptive account of the vegetation of the Western Ghat region. The habitats under which the descriptions are grouped have been distinguished in accordance with the conditions just portrayed. The most important distinction within the region is that within the two slopes of the range, which are designated the windward and the leeward rather than the Western and the Eastern, in order to empha-

size that the climatic difference between them is due, in a greater measure, to the western rain bearing wind than to their geographical orientation (aspect). Next in importance as a distinguishing factor is the topography, which leads to a sub-division into valley bottoms (ravines), slopes and ridges or tops.

51. The windward valley bottoms exhibit in a most striking degree the characteristics of the evergreen forest, and the other habitats have been treated from the point of view of their departure from them. So far as their relative area is concerned, the slope forests far exceed the other types, but their characteristics and vegetation are intermediate between those of valley bottoms and ridges.

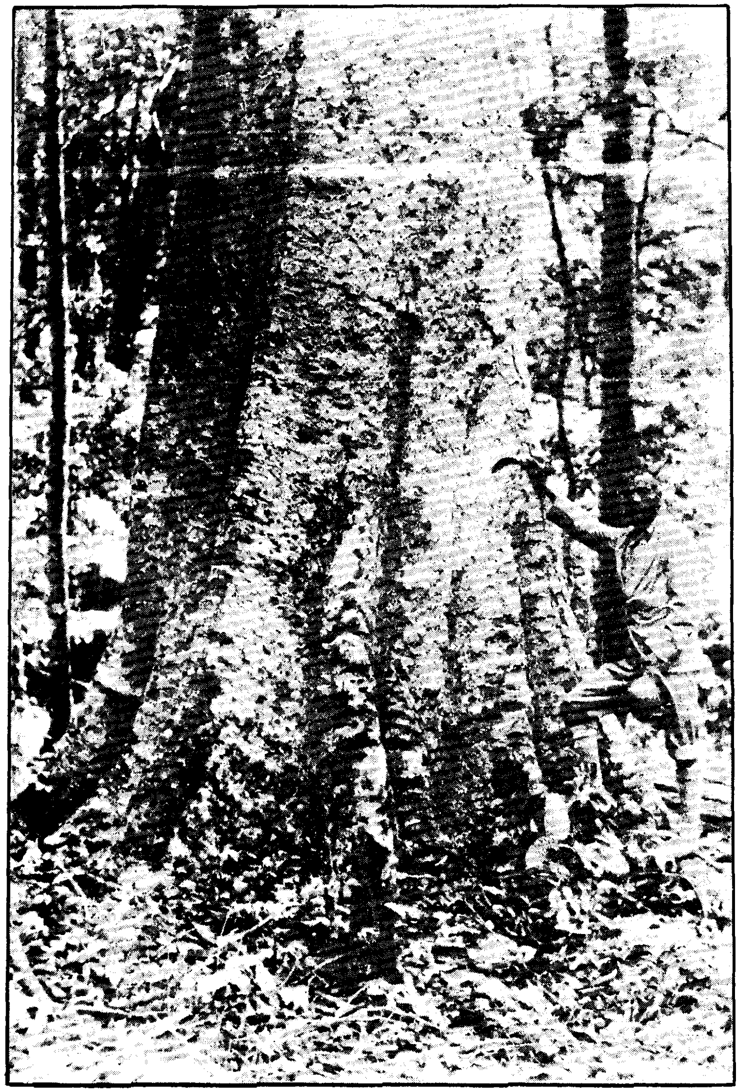
II. THE WINDWARD VALLEY

52. The valley-bottoms and ravines exhibit to the highest degree all those features of the climate and vegetation which find expression in the term "evergreen tropical rain forest", although they show quite as strongly as do the hill slopes and tops the special ghat-head features which distinguish the entire region from the rain forests which inhabit the sea-coast region below them or the tableland of Mysore above them. In the valley-bottoms, at least, are trees of stately size forming a more or less continuous canopy, beneath which smaller trees and shrubs fill all the space with a mass of foliage whose density varies according as the main canopy is more or less open. The floor of the forest is covered with flowering plants (Photo 4), natural regeneration of the larger tree species or terrestrial ferns which, in turn, vary in their density with the density of the tree-stand immediately above them. On leaning trunks and horizontal limbs or in tree pockets formed by the branch systems of trees are occasional colonies of epiphytic ferns, orchirds, aroids and other flowering plants. Occasionally, when the trees are standing exposed directly to the west wind, garlands of the lichen Usnea hang from twigs of the larger and smaller trees while musci of the genus *Polytricum*, *Bryum* and *Funaria* clothe the windward side of tree trunks and branches forming a dense mass. Tree ferns are rare and stand singly or in groups in places where some moisture percolates from the soil, either beneath the shade of the largest trees or exposed to the sky on road cuttings or land-slips. Climbers and lianes are not abundant where the uppermost leaf canopy is complete, but where light penetrates into the forest, as for example along water courses and road cuttings, they are very abundant and often envelope the trees in such a manner as to render their crowns and trunks only scantily visible.

53. A large number of species of trees and shrubs together with a considerable number of herbaceous flowering plants mingle with a relatively small number of ferns, mosses and liverworts to constitute a type of forest which is rich both in species and individuals equalling the best developed tropical evergreen forest. Though varying from place to place in the arrangement of its component species the forest exhibits a common tropical characteristic of great disorder in space.

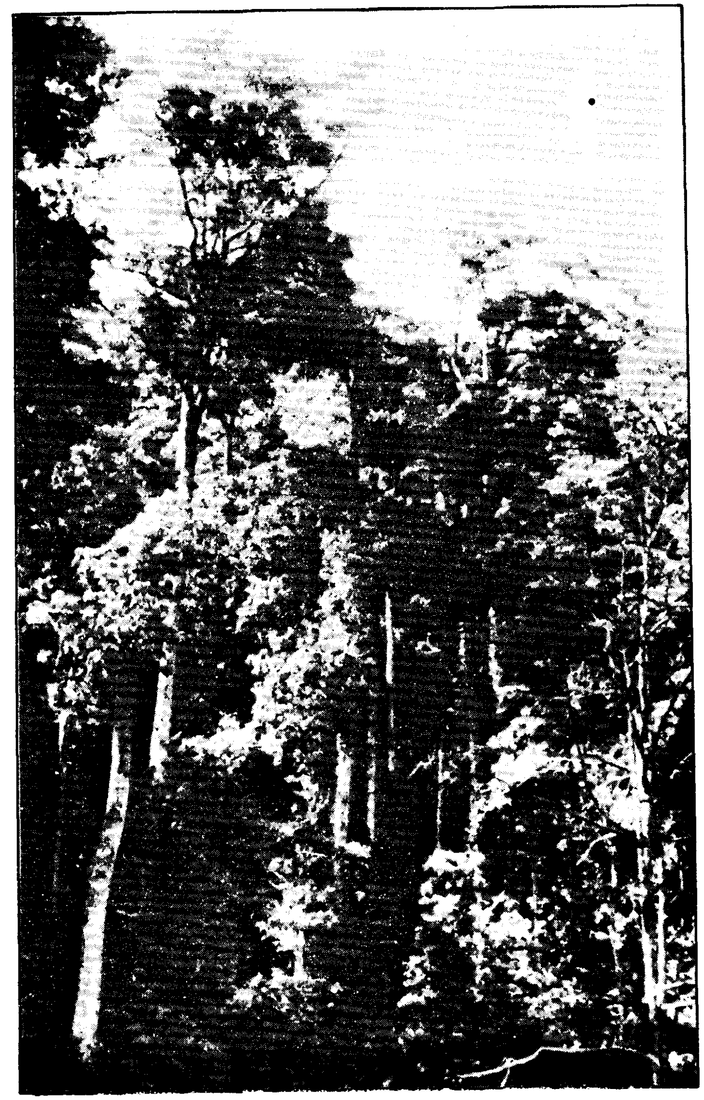
54. The windward valleys which are deep and relatively narrow (ravines) are sometimes enveloped at the height of noon with a floating fog in summer but it is covered with a cloudy mist most of the time during the rainy season. During the cold season a thin fog covers the area occasionally during the early hours of the morning till the sun rises. The constancy and height of the atmospheric moisture is one of the most potent factors in determining the character of the vegetation of valley-bottoms and ravines as well as in differentiating them from other habitats. Caused primarily by abundant rainfall, percolating soil moisture and the open watery surface of perennial streams, humidity is maintained near the saturation level through the immence evaporating surface provided by the litter on the ground, the transpiring leaf surface of the forest and the sponge like masses of musci and liverworts. Sheltered relatively from the winds which sweep over the ridges and peaks, the deep valleys are protected also from the midday rise of temperature by the dense overhead forest canopy, the masses of intervening foliage and sometimes the general fogginess of the atmosphere; by virtue of these conditions the constancy of the high humidity remains almost unbroken. The influence of the afternoon sunshine which increases the temperature and thus tends to lower the humidity operates only a few hours of the day, but this is offset by an increased rate of evaporation from the wet surfaces. Continued prevalence of dry, hot weather

PHOTO 7



A large tree of *Dipterocarpus indicus*, 15 feet 4 inches in grith, typical of its kind in the evergreen forest.

PHOTO 8



In the rest of the forest which forms the bulk of the evergreen vegetation and displays a most confusing systematic array of [illegible] not so obvious

PHOTO 9

Where some sunlight reaches the soil appear a multitude of herbaceous plants among which is the wild cardamom. The palm in the background is *Pinanga dicksoni*—the most characteristic of its kind in the understorey of the evergreen forest.

Photo. Author.

PHOTO 10

A tree of Kingiodendron pinnatum overladen with Entada scandens, in Kemphole forest. This is one of the valuable and characteristic trees in the windward valleys.

Photo. Author.

conditions through many days, as it happens in summer, however, lowers the humidity at the forest floor during that season with results fatal to some of the terrestrial herbaceous plants and the more hygrophilous epiphytes. This condition one can see during the hot months of February to April year after year.

55. The lowering of humidity in summer has also a far reaching effect on the tree species themselves. Although the evergreen forest, in contrast to the deciduous one, has no pronounced shedding season, a heavy leaf-fall takes place during the driest part of the year, and the thinnest clothing of foliage is found upon the trees at this time.

56. When the top canopy of the valley forest is seen from an opposite elevated point or an adjacent slope it presents sometimes great irregularity of surface and in summer a varied mosaic in which various shades of green are present. An experienced forester can recognize many valuable trees in the forest by the tint of their foliage, and he often gets a better picture of the relative abundance of important species while looking down upon the canopy from a vantage point than while walking through the growth on the forest floor. The largest trees stand well apart from one another, while in between them the canopy is formed by the crowns of smaller trees even of much smaller melastomaceous or rubiaceous underwood and undergrowth. The last case is invariably due to accidental fall through wind or erosion of some of the largest trees and the slowness of the subsequent repair of this break. Among tree crowns recognizable by their colours in summer are : *Schleichera trijuga* and *Canarium stricum* by their bright copper colour, *Litsea wightiana* and *Litsea* species by their light orange yellow young foliage, *Calophyllum elatum* by the dull green-brown colour of its leaves and branches, *Holigarna arnottiana*, *Holigarna grahmii*, *Bombax malabaricum* and *Sterculia guttata* by their leafless crowns, *Lagerstroemia lanceolata* by its whitish yellow crowns caused by the abundance of flower heads and others.

57. The top storey of the forest is composed of trees which, generally, raise their crowns well over the rest of the forest canopy and unfurl their full foliage to the sun (Photo 6). Though, numerically, the trees of this layer form only a small proportion of the growing stock, yet they contribute most to give the vegetation its stately look and form. Many of these trees reach, when full grown, heights of 150 ft. and girths of 14 feet and over (Photo 7). Among them are *Dipterocarpus indicus* (*halmaddi*), *Dichopsis ellipticum* (*halganne*) *Kingiodendron pinnatum* (*yennemara*), *Calophyllum elatum* (*bobbi*), *Vateria indica* (*hagenmara*) and, occasionally, the wild mango.

58. "In* the rest of the forest which forms the bulk of the evergreen vegetation and displays a most confusing systematic array of species, the distinction into tiers of growth is not so obvious (Photo 8)†. Based, however, on their capacity for maximum height growth the trees could be artificially separated into about four tiers of growth. In the first tier one finds the following trees :

Mesua ferra (*balagi*), *Hopea wightiana* (*kare-hagalu*), *Holigarna arnottiana* (*Kutageeri*), *Holigarna grahmii* (*tatagiri*), *Eugenia sp.* (*malekunna*), *Canarium strictum* (*guggala*), *Diospyros sp.* (*karemara*), *Cinnamomum macrocarpum* (*yelaga*), *Litsea wightiana* (*hammadde*), *Mastixia arborea* (*vadare*), *Actinodaphne hookerii* (*yelele-hammadde*), *Aglaia odoratissima* (*kengavara*), *Ficus nervosa* (*kanathi*), *Garinia sp.*, *Cedrela toona* (*nogavara*), *Myristica magnifica* (*natwara*), *Bischoffia javanica* (*gobarnerlu*), *Machilus micranta* (*battagumbala*), *Lophopetalum wightianum* (*hebbale*), *Artocarpus hirsuta* (*hasenamra*), *Antiaris toxicaria* (*gaddahasave*), *Lagerstroemia lanceolata* (*nandi*) and a host of others. In addition, the advance growth of the tree species of the top canopy layers fills the space.

59. The next tier is composed of moderately large trees which fill up the bulk of the space within the forest with their abundance of species and individuals. Among them are *Schleichera trijuga* (*sagade*), *Artocarpus lakoocha* (*vatehuli*), *Myristica malabarica* (*natwara*), *Litsea zeylanica*, *Litsea glabra*, *Nephelium longana* (*male-sagade*), *Garcinia cambogia* (*mantahuli*), *Garcinia indica*, *Ostodes zeylanica* (*balevara*), *Ficus sp.*, *Michelia nilaghirica* (*karivala*), *Eugenia jambolana* (*nerlu*), *Garcinia morella and several others.*

* " Indian Forester ", April 1939 ; page 195.

† " The Montane Evergreen Forest, Bisale Region " by Krishnaswamy Kadambi.

60. Another distinct tier of trees can be made out, which consists of smaller trees and form what we may call the underwood. Among them are *Humboldtia brunonis* (*yesagi*) which is sometimes gregarious in small groups, *Lansium anamalayanum* (*chigatamari*)*, *Memecylon edule* (*udatale*), *Glochidin sp.* (*hanchatte*), *Eugenia laeta* (*gondechaplu*), *Heynea trijuga* (*kaggatti*) and *Pithecolobium bigeminum* (*korachatte*)*.

61. A layer of shrubby growth generally covers the ground where there is some light filtering through, and in such places one finds *Psychotria truncata*, *Psychotria dalzelli*, *Webera corymbosa*, *Ixora nigricans* and other shrubs of Rubiaceæ. The palm *Pinanga dicksonii* (*geradalu*) belongs to this tier of growth, but it prefers places where a certain amount of overhead light is available.

62. The herbaceous plants are scanty in the denser portions of the forest where very little light reaches the soil, and a few ferns here and there is all that could be seen. Where some sunlight reaches the soil appear a multitude of herbaceous plants, among which wild turmeric, wild ginger, wild cardemom (Photo 9), *Clerodendron infortunatum*, wild *Amorphophallus* and others are common.

63. Where owing to an accidental break in the canopy the ground is flooded with sunlight, a host of fast-growing, light demanding species appear rapidly to fill up the space. Among them are *Leea sumbucina* (*vatabadakalu*), *Callicarpa lanata* (*ibbane*), *Trema orientalis* (*gorakallu*), *Macaranga roxburghii* (*upranti*), *Pterospermum sp.* (*tagadupranti*) and others.

64. The ferns often make a fine display along road cuttings. A couple of them attain large sizes and are erect. They are *Angiopteris evecta* (Photo 4) and *Alsophila glabra* (Photo 1). Their associates are *Blechnum orientale*, *Adiantum caudatum*, *Pteris quardriaurita*, *Nephrodium sp.*, *Polypodium sp.*, *Lastrœa calcarata* var. *ciliata* and others. Among epiphytic ferns the oak-leaved *Drynaria quercifolia* is very common while the birds-nest fern *Asplenium* sp., is less so. A good number of ferns, mosses and liverworts appear during rains, but the majority of these disappear with the return of summer. Among liverworts and mosses are the genera *Riccia*, *Marchantia*, *Anthocercos*, *Fossombronia*, *Trichomanes*, *Funaria* and *Polytrichum*. The bark algæ *Chroolepus* and *Scytonema* are pretty common in the rains while a host of fungi, too numerous to mention, develop to throw out their sporophores soon after the heaviest rains cease. Among the last Agaricaceæ and Polyporaceæ are most conspicuous, while the prettiest are the Dictiophoras or stink-horns, which develop their short-lived pink or white nets at the end of the rains.

65. Among the erect palms are, in addition to *Pinanga dicksonii* already mentioned, two others—*Caryota urens* (*bagani*) and *Arenga wightii* (*nepalu*), while the climbing palms are represented by no less than six species of Calamus†,—among them being *Calamus thwaitesii*, *C. pseudotenuis*, *C. rheedi*, *C. rotang*, and two other species. They are known by local names *handibetta*, *halubetta*, *nirubetta*, *simbibetta*, *sannabetta* and *nagabatta*. The last is found generally below an altitute of 500 feet.

66. Among bamboos the genus *Oxytenan thera* alone is represented by no less than four species, called locally by the names *bellote*, *nujarote*, *karote* and *ameote* and some of these occasionally form "brakes" along water courses.

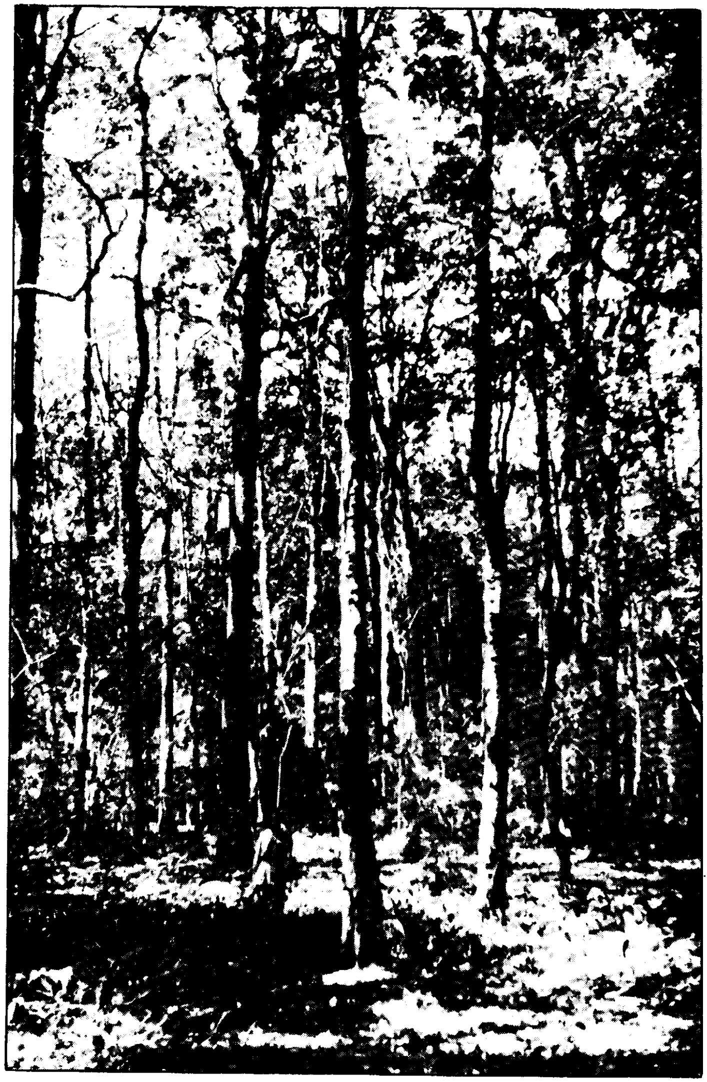
67. Climbers are a very important feature of the vegetation, especially along streams. A host of these is seen in the forest whose systematic identity is, in many cases, doubtful. Among them are, apart from the climbing palms (*canes*) already mentioned, the following :—

Gnetum scandens (*kambalibilu*), *Neravelia zeylanica* (*serebilu*), *Clematis gauriana* (*mandrike-hambu*), *Hibiscus furcatus* (*gauribilu*, *muradalebilu*), *Spatholobus roxburghii* (*ujinabilu*), *Acacia sp.* (*goddusigebilu*), *Dalbergia rubiginosa*, *Cæsalpinia sp.* (*yethugatimullu*), *Bauhinia phœnicea* (*basavanapadada bilu*), *Entada scandens* (*anemettinabilu*), *Strychnos colubrina*, *Grewia sp.* (*Mudugaranabilu*), *Neravelia zeylainca*, *Lettsomia elliptica*, species of *Ipomea* and *Convolvulus*, *Cocculus*

* Name of Agumbe region ; this tree has no local name in Hassan ghats.

† The systematic identity of these is doubtful, and it is likely that on correct determination one or two of them will turn out to be new species.

PHOTO 11

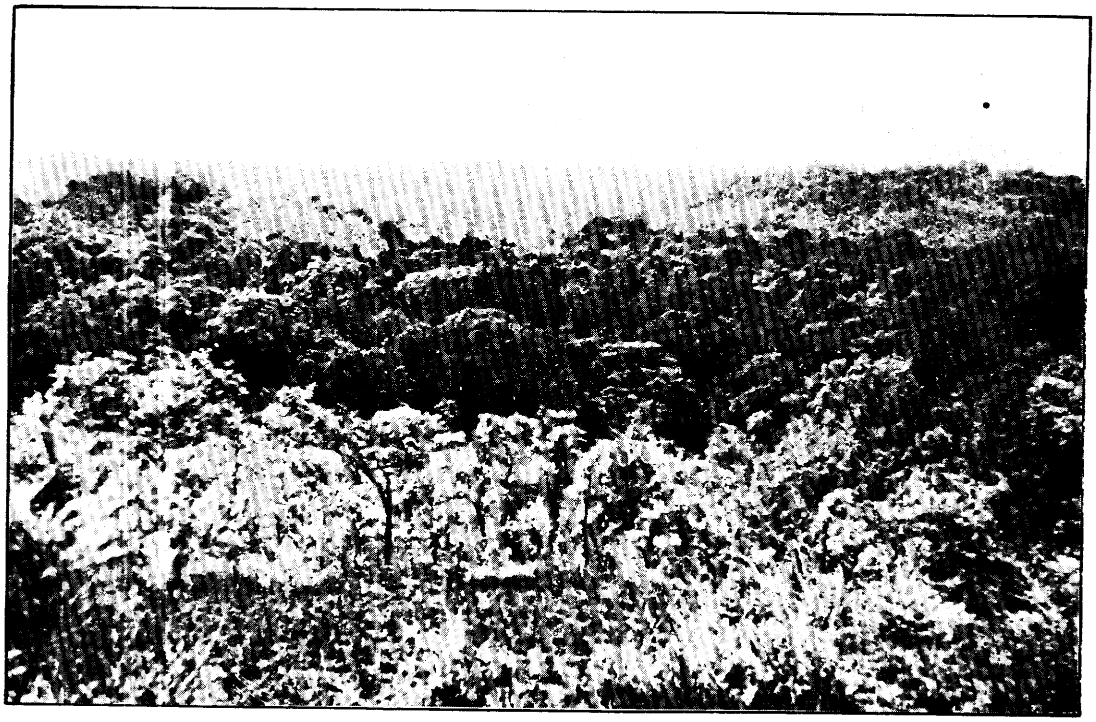


As one descends a windward valley and proceeds to the western frontier of Mysore, Xylia xylocarpa increases rapidly in abundance and forms, in places, nearly pure patches.

PHOTO 12

A tree of Dipterocarpus idicus in a windward valley. These trees, when full grown, spread their crowns laterally and unfurl their full foliage to the sun.

PHOTO 13



On emerging from a windward valley and climbing to its upper slopes a number of notable changes in the vegetation are seen at once. The height and stature of trees is much less, and the tree canopy is more open.

Photo. Author.

PHOTO 14

Limit of tree growth on the windward side of a ridge. Trees of *Pterospermum heyneanum* with fan shaped crowns, and forest ending in shrubby, low trees, then *Ligustrum* bushes and finally grass.

Photo. Author.

macrocarpus, *Tinospora cordifolia*, about 4 species of *Vitis* of which *Vitis latifolia* is one, *Thunbergia mysorensis*, *Gloriosa superba*, *Pothos scandens*, *Piper argyrophyllum* and other species of wild pepper and a host of others.

II (*a*) *Altitudenal growth-zones of the windward valleys*

68. Two altitudenal zones are distinguishable, governed probably by varying temperature and recognized by the varying distribution of important tree species :—

Zone 1 :—The zone of semi-evergreen growth passing on to the mixed deciduous one with decreasing elevation ; this extends from the toe of the ghat (elevation of about 400 feet) up to an elevation of about 800 feet.

Zone 2 :—The zone of the richest, tropical evergreen growth ; this extends from about 800 to about 2,000 feet.

69. *Zone 1* :—This contains an intimate and rich mixture of evergreen species with a few deciduous ones, and it occupies the lower half of the steep, western slopes of the ghat. Floristically, it is characterized by the absence of one of the most valuable tree species namely *Dipterocarpus indicus* and by the relative diminution in numbers of trees of *Mesua ferrea* or by their entire absence. At the upper limit of this zone *Kingiodendron pinnatum* (*yennemara*) is fairly common (Photo 10), but this also disappears with decreasing altitude. Among important trees of this zone are *Hopea parviflora* (*kiralbogi*), *Hopea wightiana*, *Artocarpus integrifolia* (*halasu*), *Artocarpus hirsuta*, *Acrocarpus fraxinifolius*, *Lagerstroemia lanceolata*, *Grewia tilæfolia*, *Stereospermum chelenoides* (*massivara*), *Oroxylum indicum*, *Sterculia guttata*, *Garcinia sp.*, *Schleichera trijuga*, *Eugenia jambolana*, *Erythrina stricta*, *Mangifera indica*, *Vateria indica* (along streams), *Diospyros sp.*, *Calophyllum wightianum* (along streams), *Bombax malabaricum* and others. This forest passes on, almost by imperceptible stages, into the mixed-deciduous one by the decrease in number of the evergreen trees, and the increasing abundance of *Lagerstrœmia lanceolata* (*nandi*), *Grewia tilœfolia* (*tadasal*) and the appearance of *Terminalia paniculata* (*hulisagade*), *Terminalia tomentosa* (*mathi*), *Terminalia belerica* (*tare*), *Pterocarpus marsupium* (*honne*), *Garuga pinnata* (*godda*), *Xylia xylocarpa* (*jambe*), *Dalbergia latifolia* (*beete*) and *Adina cordifolia* (*yethyaga*).

The canes and other palms which are abundant at the top of this zone are replaced by the big bamboo (*Bambusa arundinacea*) at the bottom of it. *Xylia xylocarpa* increases rapidly in abundance as this zone passes on to the typically deciduous one and forms, in places, nearly pure patches (Photo 11). In the underwood occasionally *Helictres isora* (*kadehurukla*) also appears.

70. *Zone 2* :—This zone contains the typical evergreen forest of the ghats. It is limited below by the zone 1 now described, and above by the region of ridges and hill tops. While the transition from this zone to zone 1 is gradual and imperceptible, the transition from it to the region of ridges and tops is almost abrupt ; the dense, tall, evergreen growth ends suddenly in relatively low, open trees and finally in grass.

71. It is not the elevation of the locality that sets this abrupt limit to the magnificent forest growth but the outcropping of gneissic rock resulting in the absence of soil combined with the high wind on exposed ridges and the fierce western sun which heats up the exposed rock. Occasionally, fire, too, plays its own part detrimentally to tree growth.

Associations of tree species in windward valleys

72. Three conspicuous ones are recognizable, one of them, at least, governed by edaphic factors. They are :

(1) The *Palaquium-Dipterocarpus association*.

(2) The *Hopea wightiana association*.

(3) The *Vateria indica association*.

(1) *The Palaquium-Dipterocarpus association.*

Underwood :—*Humboldtia brunonis*.

73. This occupies all the well drained, moderately sloping and most fertile soil of the locality. The prominent trees are *Palaquium ellipticum* and *Dipterocarpus indicus* (Photo 12). There are a host of associates ; prominent among them are *Hopea wightiana*, *Mesua ferrea*, *Kingiodendron pinnatum*, *Schleichera trijuga* and species of *Myristica*, *Holigarna*, *Garcinia* and *Diospyros*.

74. *Underwood* :—This is composed chiefly of *Humboldtia brunonis* with occasional trees of *Lansium anamalayanum*, especially at the top end of this zone.

(2) *The Hopea wightiana association* :—

75. This covers the steeper slopes merging into ridges. The ground is well drained but, being generally too steep, some of the fine disintegrated organic matter is washed down to the valley resulting in relatively shallow and moderately poor soil.

76. *Associate species* :—*Schleichera trijuga*, *Mesua ferrea*, species of the genera *Garcinia*, *Diospyros*, *Myristica* and *Litsea*, *Cinnamomum macrocarpum* (*yelaga*), *Alstonia scholaris* (*kodiyala*) and others.

Underwood :—*Memecylon edule* (*udatale*), *Diospyros sp.*, and others, but these do not form a distinct layer. The forest is generally lower and more open than in Association No. 1. Unlike it, also, natural regeneration of all species and especially of *Hopea wightiana* is very abundant.

(3) *The Vateria indica association* :—

77. This is an edaphic variant on associations (1) and (2) above. Trees of *Vateria* cover the beds and banks of all streams, often forming as much as 90 per cent. of the tree-stand in such localities. Its chief associates, though for behind it in numbers, are *Gordonia obtusa* (*nagaramara*) in the upper portion of the zone, *Lophopetalum wightianum* in the lower portion, *Calophyllum wightianum* (*hole-honne*), *Mangifera indica*, *Mastixia arborea* (*vadare*), *Carallia lucida* (*torahalasu*), *Myristica sp.*, (*kokkaberumara*)*, and *Hydnocarpus wightiana* (*kalduvala*).

78. *Undergrowth* :—This varies greatly. Sometimes there is none at all, the ground being filled by natural regeneration of *Vateria indica*. At other places, where sunlight reaches the soil, species of *Oxytenanthera* (*vate*), the cane "*nirubetta*" or the screw-pine (*Pandanus*) sometimes choke the beds of streams and make human passage nearly impossible. Where drainage is good, one also finds *Vitex leucoxylon* (*hole-nakki*) and *Eugenia læta* (*chappalu*) ; where drainage is somewhat wanting the Wild plantain (*Musa superba*), *Alpinia sp.* (*pogalu*)† and *Bragantia wallichi* fringe the streams.

79. In some places, especially at lower elevations, trees of *Lophopetalum wightianum* often increase in abundance and claim an important place in the crop, even rivalling *Vateria* in the number of individuals. Gigantic buttressed specimens of this can be seen in Kemphole forest.

80. Climbers sometimes play a prominent part in the association, these being particularly abundant in some places where they envelop the tops and trunks of trees with their foliage, thus strangling their supporters. *Entada scandens* is the commonest and worst of such offenders, while *Bauhinia valhii* is not much better, though it is rarer.

III. The Windward Slopes, Ridges And Tops

81. On emerging from a windward valley and climbing on to its upper slopes a number of notable changes in the vegetation are seen at once. The height and stature of trees are much less—about 80 feet or so—and the tree canopy is much more open (Photo 13). The trees exhibit much diversity in trunk diameter. They, occassionally, lean to a side where a shifting of the land surface downward has occured, and sometimes they are fallen. The undergrowth is more dense and the herbaceous terrestrial vegetation is less abundant than in valleys, but natural regeneration of the tree species is more abundant, saplings and poles often forming a dense mass. The number of ferns (pteridophytes) is also less, but climbing and epiphytic species are more conspicuous by reason of their here occupying a place nearer the floor of the forest‡. On well exposed ridges the hanging lichen (Usnea) is conspicuous, the tree ferns are absent but thicket forming ferns are occassionally encountered.

82. The windward slopes vary in their character according as they are nearer the bottom of a valley or nearer a ridge, and their vegetation is little more than a mean between the pronouncedly hygrophilous ravines and the open xerophytic ridges. The slopes which lie just below gaps or hill saddles are somewhat similar to the valleys, because through these

* This tree has no local name, and the name from Agumbe-Kilandur zone has therefore been mentioned.
† Generally called *dantaga* in Agumbe-Kilandur zone.
‡ A Montane Rain-Forest by F. Shreve, Washington, D.C., published by the Carnagie Institution, 1914 ; page 31.

gaps in the main ridge clouds roll almost continuously during rainy season and shed their moisture.

83. The effect of wind on tree growth is most conspicuously seen in this region, but it is probably not wind alone which is responsible for the gradual dwarfing of trees and their ultimate disappearance but also the decreasing depth and fertility of soil and the increasing rapidity with which soil dries up.

84. On going up a windward valley to the windward slope and then on to its ridges and finally up the ridge to a hill top, one sees every transition from the most luxurient valley (*shola*) forest to grass and, finally, bare rock. It is not the elevation above sea level that sets a limit to this tree growth, but the outcropping of rock and consequent absence of soil, combined with high wind on exposed ridges and the accompanying increased evaporation, as well as the hot, continuous western sun of summer with its severe dessicating effect. This last factor is enhanced by the rapid heating and cooling of the exposed rocky surface. Finally, the shallow soil which is unretantive of moisture owing to washing out of the organic matter by very heavy seasonal rains, and the occasional advancing grass fires of summer which sweep up from the ground and destroy all trees growing at the edge of forest, except the larger ones, add to the factors which inhibit tree growth.

The growth zones of the windward slopes, ridges and tops

85. Three zones are here distinguishable, varying with exposure and aspect.

(1) The region of transition from valleys to ridges, where the vegetation represents a mean between the tall growth of the valley and the dwarf growth above it.

(2) The region of dwarf trees, ending in *Strobilanthes*.

(3) The treeless grassy ridges and tops.

86. To these, occasionally, a fourth namely, the region of bare sheet rock capping the higher hills, may have to be added.

(1) *The region of transition from valleys to ridges*

87. This region generally descends from region (2) above down along exposed ridges into valleys, sometimes to very low altitudes (600 feet) on the wind exposed and sunny western aspect ; it projects sometimes deep into valleys in the form of tongues of growth and passes on into the valley vegetation with increasing protection from wind and sun. The stature of the forest, compared to that in the valleys, is low, relatively open, sometimes richer in epiphytes and climbers, and with a denser undergrowth in which natural regeneration of the local tree species are more conspicuously represented.

88. Floristically, the important tree association is that of *Hopea wightiana* (*kare-hagalu, kare-haiga*). This species tends in its growth to exclusiveness and forms, in some places, about 70 per cent. of the tree growth by numbers. It also regenerates itself profusely and, while passing through the forest, one is astonished by the abundance of its seedling regeneration and advance growth. Among the species associated with it are *Diospyros sp.* (*kari-mara*), *Schleichera trijuga* (*sagade*), *Garcinia cambogia* (*mautahuli*), *Garcinia morella*, *Lagerstrœmia lanceolata* (*nandi*), *Bombax malabaricum* (*buruga*), *Garuga pinnata* (*godda*), *Mesua ferrea* (*balagi*), *Dispyros sp.* (*yennebadakalu*), *Euonymus indicus* (*bennemuthaga*), *Eugenia sp.* (*mattanerlu*), *Evodia roxburghiana* (*devagare*), *Mimusops elengi* (*kari-bakula*), *Litsea wightiana* (*hammadde*), *Litsea sp.*, *Actinodaphne hookerii* (*yelelehammadde*), *Memecylon sp.* (*chappalu*), *Olea sp.* (*bangarasadle*), *Glochidion lanceolarium* (*hanchatte*) and others. The natural regeneration of all tree species is always abundant, and this, along with the dense undergrowth of *Psychotria dalzelli*, *Unona pannosa* and others impede the easy passage of human beings. Among climbers, canes are common. On descending from the ridge to the streams which flow beneath abundant *Vateria indica* appears.

89. The species *Dipterocarpus indicus*, *Vateria indica* and *Dichopsis ellipticum* are generally absent on ridges.

(2) *The region of dwarf trees ending in Strobilanthes*

90. In this zone the forest contains some species which are generally natives of the mixed-deciduous or even of the dry-deciduous forest type, but trees of such species are few,

and they are intimately mixed up with the evergreen growth. Trees of the evergreen forest found here are generally low and stunted. Their bole length diminishes gradually as one approaches the upper tree limit, and they are branchy from near the ground level. Among genera and species of this zone are :—

Symplocos spicata (*turublu*), *Plectronia didyma* (*abbalu*), *Tabernœmontana dichotoma* (*maddarasa*), *Eugenia sp.* (*mattanerlu*), *Eugenia corymbosa* (*kunnerlu*), *Olea dioica*, *Cinnamomum zeylanicum* (*yelaga*), *Memocylon edule*, *Melastoma malabathricum*, *Glochidion lanceolarium* (*hanchatte*), *Schleichera trijuga*, *Flacourtia sp.* (*kullajepalu*), *Lagerstrœmia lanceolata* (*nandi*), *Erythrina sp.* (*keechaka*), *Ficus sp.* (*bendarali*) and others.

91. This collection of branchy, or sometimes even bushy trees ends often in a fringe of bushes of *Ligustrum neilgherrense* on the edge exposed to wind, or in *Strobilanthes* bushes in less exposed situations. The belt of *Strobilanthes* fringes the dwarf forest like a ribbon all along its edge and three to four species of this genus are found, the commonest among them being *S. callosus*. Their juicy and brittle stems stand densely packed far above a man's height and act as a powerful brake to any advancing fire sweeping up from the grass of the hill-tops. The edge of tree growth is thus protected from fire-scortching and the regeneration of evergreen species sometimes found lurking in-between the Strobilanthes is also saved from destruction.

92. The edge of tree growth facing a gap through which there is a constant rush of western wind in summer and of misty cloud in the rainy season is composed sometimes of trees of *Pterospermum heyneanum ?* (*hunjanmara*), and these exhibit fanshaped crows covered with festoons of the lichen *Usnea* and mosses which are green in the rains but deep brown in the dry season lending their colour to the entire tree crowns (Photo 14).

93. Among climbers, straggiers and thorny bushes found in this region and also, occasionally, in region (1) described above are : *Toddalia aculeata* (*gudamenasina bilu*), *Cœsalpinia sp.* (*badabakka*), *Heptapleurum wallichianum*, *H. Sp.* (*anagalu bilu*), *Bridelia retusa* (*nelagoje*), *Rubia cordifolia* (*kaikuyyana-bilu*), *Elœagnus latifolia* (*hulugarna-balli*) and *Clematis wightiana* (*sali-maddina hambu*).

(3) *The treeless, grassy ridges and tops*

94. This region has no tree canopy, and the trees which are found in it are stunted, low-branchy, and dwarfed, sometimes hardly 20 feet high and bole-less. They generally exhibit pronounded xerophytic characters, and their natural habitat is the mixed-deciduous or the dry-deciduous type of forest. Well known trees found sprinkled in this area are :—

Terminalia chebula, T. tomentosa, T. belerica, Zizyphus rugosa, Bridelia retusa, Dalbergia latifolia, Dillenia indica and Mallotus philippinensis. Tree growth is frequently altogether absent, except for a few bushes of Wendlandia notoniana (*talige*) and the fire scortched palm Phœnix humulis, the colony forming Bracken Fern (Pteris aquilina) and, occasionally, Gleichenia dichotoma.

95. This region passes on to the evergreen forest by the gradual appearence of Plectronia didyma, Olea dioica, Symplocos spicata and species of the general Litsea, Actinodaphne, Cinamomum and others. At its upper limit the grass ends in sheet rock, generally gneiss.

IV. THE LEEWARD VALLEYS

96. The valleys of the leeward side of the Hassan ghats do not differ to any marked degree from those of the windward side and exhibit few points of contrast. The general structure of the two types is similar both in the structure of the trees and the irregular canopy which permits abundant underwood and undergrowth. Differences which, however, are not very striking are the general paucity of the forest of the leeward side in epiphytic mosses, lichens and hepatics, the scantier growth of epiphytes, the greater scarcity of tree ferns and the inconspicuousness of filmy ferns. The leeward valleys receive probably, a lighter rainfall but they enjoy a correspondingly less number of hours of afternoon sunshine and are less exposed to wind ; these two factors balance the first. The result is that the leeward valleys are cooler in summer and less wind exposed.

97. Consequent on the cooler habitat and less of isolation there is considerable variation in the altitudenal distribution of zones of growth as indicated below :

Zone (1).—The zone of sub-deciduous forest up to 600 or 700 feet (against 800 feet in the windward valley).

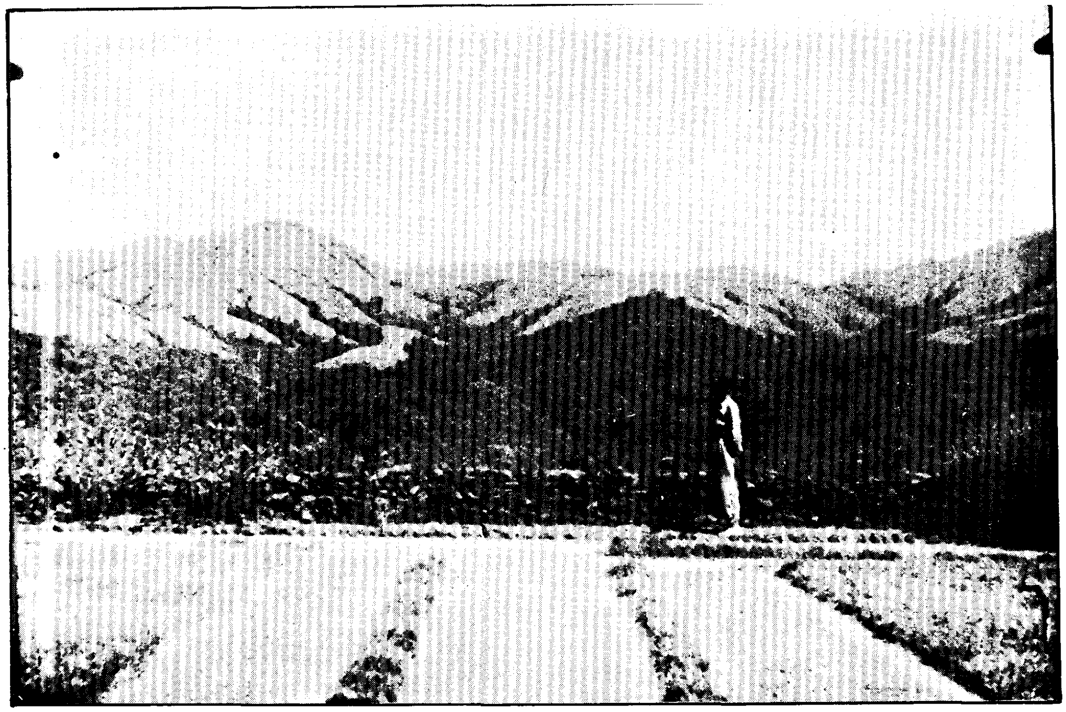


PHOTO 15

↑ A leeward top sheltered from wind by the row of higher hills beyond and fully covered by tree growth.

Photo. Author.

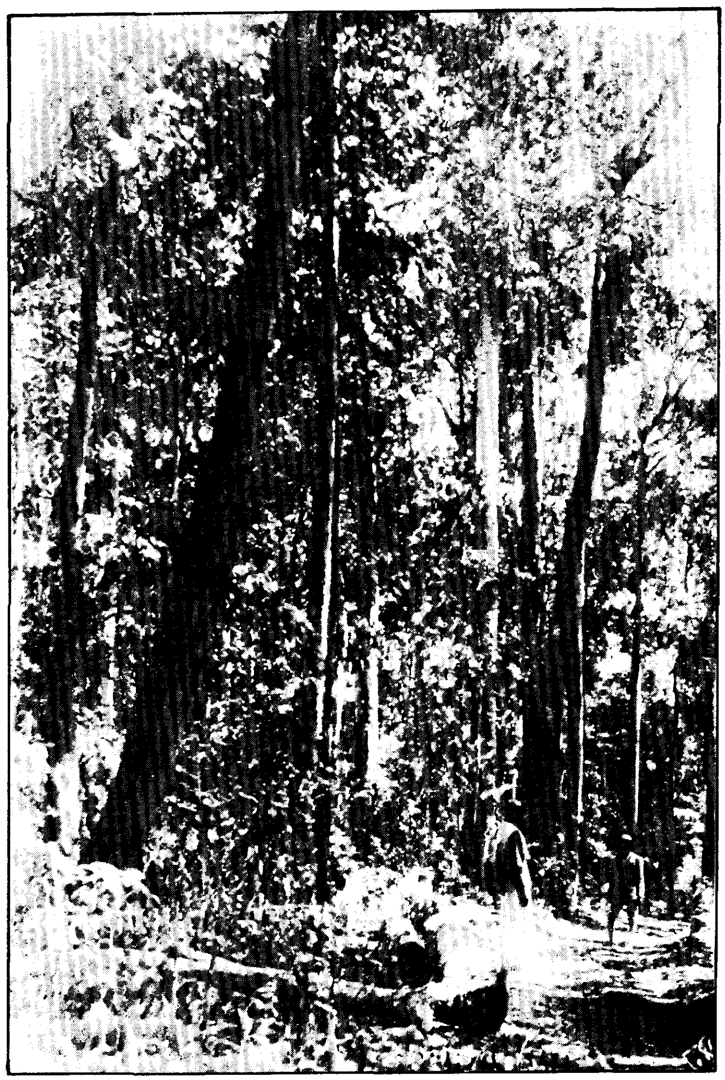


PHOTO 16

→

Sometimes one passes through immence, dark columned halls where owing to the relative scarcity of the undergrowth there is a fairly free passage and clear outlook in all directions.

Photo. Author.

PHOTO 17

Approaching. . . . . .the borders of the perennial streams the forest displays a very dense mass of foliage through which one can make his way only with some difficulty or. . . . . .

Photo. Author.

PHOTO 18

These two extremes are connected by every stage of intermediate form where more or less abundant underwood appears.

Photo. Author.

Zone (*2*).—From 600 or 700 to 2,200 or 2,300 feet (against 2,000 feet in the windward valley).

This zone passes into the zone of leeward ridges and tops which unlike on the windward side, are generally clad with forest.

98. The commonest trees of this habitat are *Hopea wightiana* and *Palaquium ellipticum*. Among their assocsiate are *Litsea sp.* (*kapuramara*), *Mimusops elengi* (*bakula*), *Dillenia sp.* (*malenerlu*), *Schleichera trijuga*, *Calophyllum elatum*, *Mastixia arborea* (*vadare*), *Diospyros sp.* (*kaggatti*), *Mesua ferrea*, *Myristica magnifica*, *Garcinia cambogia*, *Garcinia sp.*, *Litsea wightiana* (*hammadde*), *Ficus nervosa* (*malegargatti*), *Cinnamomum macrocarpum*, *Elaœocarpus munroii* (*naitupru*), *Elaœocarpus sp.* (*tupru*), three species of *Holigarna* and others for which it has not been possible to secure botanical determinations. Occasional trees of white cedar (*Dysoxylum malabaricum*), *Chrysophyllum roxburghii*, *Alstonia scholaris*, *Aglaia roxourghiana*, *Artocarpus hirsuta* and *A. integrifolia* are also seen.

99. Among the smaller trees are again a host of species. They are *Plectronia didyma*, *Diospyros sp.* (*yennehidaklu*), *Eugenia hœmispherica*, *Eugenia corymbosa*, *Evodia roxburghiana* (*makli*), *Holigarna sp.* (*kadugeru*), *Diospyros sp.* (*sungaralakki*), *Lansium anamalayanum*, *Garcinia morella* (*kaggatte*) and others.

The scarcity or absence of *Dipterocarpus indicus* and *Kingiodendron pinnatum* from leeward valleys is noteworthy.

V. THE LEEWARD SLOPES, RIDGES AND TOPS

100. The slopes, ridges and leeward tops sheltered from wind present a contrast to the windward ones because they are usually fully covered by tree growth (Photo 18) almost to the tops and the limit of tree growth is determined *by the degree of direct wind exposure*. Wind also determines the stature of trees; those standing close to the tops of ridges on the leeward side have their height growth limited to the ground level of the ridge. In the case of tops directly exposed to western wind, the tree growth clings to the leeward, eastern and north-eastern, side and its upper limit is set only by the appearance of sheet rock.

101. The arborescent flora is richer than on windward slopes and spurs. The stature of the forest is also better and individuals of every diameter class, large and small, are intermingled to form a closed canopy. On steeper slopes there is not much distinction between the crown levels of larger trees and those of smaller trees and shrubs, so that there is sometimes a solid mass of foliage from ground level to top canopy. The effect of wind makes itself so conspicuously felt that tree growth confines itself very closely to wind protected contours and its limit runs zig-zag clinging to the sheltered contours and limited by wind action but entirely independent of the altitude (Photo 15).

102. The hygrophilous mosses and hapatics are scarce and epiphytic vegetation is relatively scanty. Lianes are fairly common. The terrestrial herbaceous species are largely phanerogamic while pteridophytes are represented by infrequent individuals. The herbaceous vegetation is rich in species but not as rich in individuals as the most luxuriant spots on windward slopes.

VI. THE TABLELAND IMMEDIATELY ADJOINING THE WIND-EXPOSED WESTERN WELL

103. The crest of the western wall facing the Arabian Sea ends, over the greater portion of the area, in a tableland plateau, with a varying degree of undulation but generally capped by low, easy hills. On this plateau the rainfall diminishes rapidly from the ghat-head inwards and, consequently, the typically evergreen forest is confined to a narrow belt about two miles wide. Some of the finest patches of forest with tall, evergreen, unbroken canopy standing over a hundred feet from the ground is found in this area. This forest is also of much importance from the forest utilization point of view because the country is relatively easy and accessible to wheeled traffic. Its general elevation is 2,000 feet.

104. Here, in the interior of the forest, the picture varies from place to place. Sometimes one passes through immence, dark columned halls where owing to scarcity of undergrowth there is a fairly free passage and a clear field of vision in all directions (Photo 16). Approaching, on the other hand, the crest of the ghat or the borders of perennial streams (Photo

17) the forest displays a dense mass of foliage from the ground to the tops of trees, through which one can make his way only with some difficulty or be occassionally stopped by an impenetrable tangle of thorny canes and lianes or a dense mass of Pandanus growth. These two extremes are connected by every stage of intermediate form where more or less abundant underwood appears (Photo 18) (1).

105. This forest, being accessible, is of special importance to the Forest Department and its floristic composition is therefore of greater interest. Owing, however, to the existence of some coffee and cardamom estates here, the tree growth over some of this area has been interfered with or destroyed.

106. The forest is generally magnificent. Tall, cylindrical, branchless boles and full round-headed crowns characterize the trees of the top canopy which, unlike in valleys, is less broken. The cover is often so complete that the interior of the forest is dull and dark and presents a gloomy picture owing to the absence of colours except the monotonous dark green tint.

Tree Associations

107. The following are found :—

(1) *The Hopea-Palaquium association;* Underwood-*Humboldtia brunonis* and *Unona pannosa.*

(2) *The Elæocarpus tuberculatus association.*

(1) *The Hopea-Palaquium Association.*

108. The commonest trees of this forest are *Hopea wightiana* with its two varieties known locally as *karehagalu* (black variety) and *bilehagalu* (white variety). There seems to be little systematic difference between them except that the leaves and young twigs are lighter green in the latter and darker-green (the twigs approaching dull black) in the former. Next in abundance is *Palaquium ellipticum* which is among the tallest and most stately of the trees of this zone. Among the others are *Mesua ferrea, Canarium strictum, Eugenia arnottiana, Litsea wightiana, Calophyllum elatum, Diospyros sp., Cinamomum macrocarpum, Mimusops elengi, Artocarpus hirsuta* and, occassionally, the white cedar.

109. The undergrowth may or may not be dense. Where dense, the following floristic composition is seen :—

Humboldtia brunonis (*yelale*) is the commonest tree ; its growth often approaches purity and presents a beautiful appearance with its dissected fern-like leaves and erect racemes of sweet scented pink and white blossoms. This tree is common along streams. Sometimes a fairly dense growth of *Unona pannosa* is found. Among others are *Memecylon edule* (*hadathale kaddi*), *Eugenia læta* (*chappalu*), *Celtis cinnamomi* (*helupthaga*) and the palm *pinanga dicksonii*. As soil cover are found occasionally *Clausena indica* and two or three species of *Psychotria*. Where owing to an accidental break in the canopy sunlight streams in one finds *Leea aspera, Callicarpa lanata* and patches of *Strobilanthes callosus* (*guruklu*), *S. barbatus* (*hegguruklu*) and others.

(2) *The Elæocarpus Association*

110. This is an edaphic variant on association No. 1, and occupies the same position which the *Vateria indica association* does in the windward ravines. This association is more conspicuous than association No. 1 owing to the greater concentration of growth of a single species with its characteristic heavy plank buttresses (Photo 19). *Elæocarpus tuberculatus* (*hanal-tare*), which is the chief species, forms in some cases 90 per cent of the crop. This association is generally found at elevations of over 1,800 feet. It is confined invariably to the banks of streams and disappears on ascending the slopes. Among its associates there are several species which change from place to place. They are *Lophopetalum wightianum* (*hebbale*), *Carallia lucida* (*torahalasu*), *Gordonia obtusa* (*naganamara*), *Calophyllum wightianum* (*bobbi*), *Elæocarpus munrowii* (*tupru*), *Elæocarpus sp.* (*kantupru*) and *Hydnocarpus wightiana. Lophopetalum wightianum* is sometimes abundant.

111. The undergrowth in this association has various species and is often so dense that one has to laboriously cut his way through it with a sickle or be entirely stopped by an impenetrable tangle of lianes, canes or Pandanus. The species of bamboo *Oxytenanthera* also cover, in some places, the banks of streams forming a dense mass.

PHOTO 19

A tree of Elæocarpus tuberculatus with its characteristic, heavy plank buttresses.

Photo. Author.

SECTION 9.—*Epiphytes*

112. The epiphytic plants do not strike the eye immediately on entering the forest owing to their relatively very subordinate position in composing the foliage cover of the evergreen forest, but, on a closer examination, one sees that a host of them, large and small, do exist, and they exhibit striking contrasts in their demand for moisture. Some are hygrophilous in the extreme, while there are others provided with plenty of water storage tissues and are thus capable of withstanding drought for weeks or months together, and exhibit also other pronounced by xerophytic characters.

113. The larger trees in the windward ravines and elsewhere, forming the top canopy layer, are relatively poor in epiphytes excepting in their crowns where the orchidaceæ and some ferns are seen but mosses, hepatics and liverworts are generally absent.

114. Between the epiphytic vegetation of the forest floor and the canopy there are differences, and these are determined by the vertical difference between the climate of the floor of the forest and its canopy, a factor which operates on the epiphytic vegetation as much as it does upon the structure of the leaves. The leaves of *Dipterocarpus indicus* from the top level of the crown canopy and those of their seedlings from near the ground level show much variation in construction, as I have shown in a previous paper*. Schimper† first pointed out the difference between the epiphytic vegetation of the forest floor and the canopy.

115. There is also some difference between the epiphytes found in the crowns of trees standing in valleys and those found in the crowns of trees standing on the higher windward slopes and ridges, the latter being more xerophytic in their character.

116. The epiphytes found at the level of the forest floor are pronounced hygrophytes, confined to that condition by the very favourable humidity and frequent wetness. The mid-level forms, i.e., those found on tree trunks and branches of under-trees, are somewhat drought resistant or grow amidst the water storing mats of bryophytes and mosses. The epiphytes of the topmost level are pronouncedly xerophilous with water storing or water catching structures or else they are small and coriaceous.

117. The windward valleys and ravines exceed generally, the other mountain habitats in the wealth of their epiphytes, because in them are found all the characteristic forms of the whole locality under description.

118. The commonest terrestrial ferns, orchids and flowering plants are not generally found as epiphytes. Among the epiphytes are many and varied forms whose names I have not been able to ascertain except in rare cases. They are *Peperomia portulacoides* found on moist rocks and branches of trees and *Hymenophyllum exsertum*, *Trichomanes intramarginale*, *T. bipunctatum*, *Elaphoglossum viscosum*, and *Polypodium sp.* which cover the barks of trees.

119. The largest of the epiphytes are *Heptapleurum wallichianum* and *H. venulosum*, both araliaceous plants, sometimes growing independently, sometimes as half climbers but more frequently epiphytic.

120. Epiphytic orchids are not very numerous and there are not many species of them either ; so are the ferns. Among orchids are *Cymbidium bicolor*, *Oberonia recurva*, *Microstylis rheedi* and *Vanda roxburghii* which, with its "velamen" covered roots can exist under very xerophytic conditions. Among ferns are *Polypodium repandum*, *Drymoglossum piloselloides*, *Davallia bullata*, *Niphobolus adnascens*, *Drynaria quercifolia*, *Stenochlœna palustre*, *Pleopeltis hemionitidea*, *P. linearis* and *Asplenium sp.* the last of which forms at the base of its leaf rosette a birds-nest like structure said to be capable of catching and retaining moisture.

121. In the highest level of the tree tops the epiphytes are small plants in every case. The small orchids of the tree tops are all provided with water storing tissue in their leaves or bulbs, the common ones among them being *Cœlogyne sp.* with its bulbs and *Vanda roxburghii* already mentioned ; the small ferns growing here are mostly species of *Polypodium* —*P. zeylanicum* and *P. cucullatum*. A large bluish green *Usnea* and a smaller yellow species are common on tree tops particularly on the

* " Observations on the Silvicultural characters of *Dipterocarpus indicus*, etc." by Krishnaswamy Kadambi, Indian Forester, November 1936, page 9.

† Schimper A.F.W. die epiphytische vegetation Amerikas, Bot. Mittausden Tropen, Heft I, 1898.

ridges at higher elevations where they grow along with the polster mosses.

122. On proceeding from a windward valley or ravine up through the windward slope to a spur and along it to a ridge one finds the same transition in the epiphytic vegetation that might be seen by climbing a tall tree in a valley except that lichens are not so conspicuous in the tree crowns of valleys and the mid-height epiphytes of valleys are found underneath the main canopy level on the ridges. The dwarfed trees on the ridges exposed directly to the western breeze often bear the greatest wealth of epiphytic lichens and polster forming mosses both of which are strongly drought resistant and turn brown in summer.

123. Ecologically we have among the epiphytes, as already stated, a collection of members ranging from the most hygrophilous to the most xerophytic. The filmy fern *Trichomanes* found generally at the floor of the forest during rainy season dries up in a few minutes on being brought out into open sun from the shade of evergreen forest, while at the opposite extreme are the orchids *Cœlogyne* and *Vanda* which can live for four to six weeks, the latter probably much longer.

Seasonal differences in the appearénce of epiphytes

124. The year, with its striking contrast of wet and dry seasons, also produces a variation in the abundance and look of the epiphytic vegetation. In summer the fronds of a good number of the filmy ferns disappear altogether, the hepaticæ dry up and wither away, the tufts of musci get embrowned and look relatively inconspicuous, while the lichens turn whitesh-yellow or brown.

The bryophytes and pteridophytes, unlike the flowering plants which will be dealt with later, grown briskly during the rainy season, and their reproducing organs (sori) develop from October to January and wither with the onset of dry season, to remain in a stage of hibernation till the onset of the next monsoon.

(*To be Continued*)

A FOREST OUT OF THE SAND

The dramatic story of the creation of a new forest in Scotland on land that for nearly 300 years has been a desert....

BY MARTIN CHISHOLM

This is the story of an unusual piece of reconstruction in Britain that has been going on for a very long time, but so quietly that word of it hardly ever filters through into the news. It concerns the making of a forest and the turning into usefulness of land that for nearly 300 years has been a desert.

Perhaps the word "desert" sounds a strange one to use about an area of land in the north of Scotland, but on the shores of the Moray Firth, not far from the town of Inverness, there is a tract known as Culbin Sands which is, or rather was, desert country. It is an area of shifting sands and dunes in which the only signs of life are an occasional sea-bird wheeling overhead, and, here and there, the footprints of some small animal that has scurried across the dunes in search of more hospitable country.

The footprints do not stay for long because, as the prevailing wind blows in from the Moray Firth, it drives the sand before it, building it into new hillocks which, if unchecked, would engulf the richer land on the borders oi the area. If you could stand on those dunes and think back into past history you would hardly know that you were standing on top of what were once prosperous villages set in rich farm land. The villages ceased to prosper and the land became desert in or about 1694 when first the sand began to blow in from the seashore, and the fertile Barony of Culbin was engulfed.

By courtesy of British Information Services.

Two-fold Task

That, very briefly, is the background to the story. Various efforts were made by local landowners of imagination to grapple with the advance of the sands. Then, in 1921, the Forestry Commission, the body responsible for preserving and building up Britain's forests, acquired a portion of the land. In the following years more and more of the land was taken over by the Commission until eventually it had 6,000 acres in its hands.

The Forestry Commission had a two-fold task in view—to create a new forest on land that might seem useless and beyond hope to the average man, and to plant it in such a way that it would stop the movement of the sands which offered a continual threat to farms.

The planting of a new forest on shifting sands presented very special problems for the forestry experts. In the first place they had to find a means of keeping the sands still, otherwise the tiny young trees would either have been quickly buried, or else the sand would have blown away from their roots and left them to be parched to death. The solution of this problem was found in "thatching" the ground on which the trees were to be planted.

Branches and brushwood cut from other nearby plantations were spread over the sand, with the butt ends of the branches pointing in the direction of the prevailing wind. In some extra-exposed areas the brushwood was even pegged down to prevent it being blown away. Then the young trees from the Forestry Commission's nurseries were planted in the "thatched sand".

Another problem was to settle on the species of tree best suited to thrive in these desert conditions. The final choice was the Corsican pine which was found to have a strong resistance to the salt air which blows in from the Moray Firth.

4,000 Acres Planted

So far 4,000 out of the 6,000 acres acquired by the Forestry Commission in the area have been planted, and the results, to a layman's eye at any rate, are dramatic in the extreme. Twice in recent years I have visited the sands, in parts of which one could find an almost perfect location for some desert film. Walking, or rather floundering, over the unplanted part of the dunes, the going was hard and wearisome. The loose sand flowed over into one's shoes, from the top of the dry dunes sand was blowing inland like smoke from some slowly smouldering fire. Then one came among the trees.

In the newest plantations they were still small, only two or three feet high. But you could feel their presence as well as see it, for the rotting thatch of brushwood and the pine needles which had fallen even for a few seasons had begun to make the earth firmer underfoot. Walking was easier, and, as one moved from the younger to the more established parts of this new forest, the going everywhere became firmer.

The plantations have been so planned that the trees will give each other mutual protection from the prevailing wind. Their position is such that as the forest grows to maturity it will form a wind-break to prevent the further blowing of sand from the unplanted areas on to the valuable nearby farm land. This protection of the land is a long-term policy, but meantime the young forest has begun to give its creators some return. The trees must be thinned out as they grow and these thinnings are already supplying valuable pit props to the Scottish mines.

SOME ASPECTS OF SOIL EROSION IN HILLY WASTELAND

(With reference to anti-erosion mesures as being adopted in Sidh Chalehr village wasteland)

BY RAM PARKASH, M.A., B.A. (HONS.), D.D.R. (HONS.)
(*Forest Range Officer, Bharwain*)

Soil erosion signifies removal by the agencies of wind and water of the topmost layers of the earth's crust, which are rich in well decomposed organic and mineral matter and constitute the entire fertility of the locality. When once erosion has set in, and is allowed to progress unchecked, the consequences may be the removal of even the subsoil, and in really bad cases the parent rock may also be exposed. Under natural conditions of vegetative cover—trees, bushes and grasses—the natural processes of soil erosion which are always at work through the action of wind and rain, are balanced by the gradual processes of soil formation, and consequently the resultant erosion may be negligible or non-existent. It is simple to visualize that the vegetative cover prevents the direct impact of rain with the soil surface, breaks its velocity, hence the momentum, and thereby not only considerably reduces the soil carrying capacity of water, but also helps the soil to absorb and retain the water more efficiently by virtue of a network of its root system and the spongy nature of the leaf litter and the decomposed organic matter, which we invariably find on the ground covered with vegetation. It is, therefore, obvious that wherever man has disturbed the natural soil vegetation equilibrium by denudation of the forest through reckless and injudicious felling, grazing, browsing and firing, the soil has been left unprotected and exposed to the disastrous consequences of soil wash through rain and wind, which follow in its train. Vast stretches of wasteland which once supported magnificient and lofty woods in the country, and were the sports preserves of the chieftains of the time, now lie bald and bare to tell their tale of woe. The Siwaliks of Hoshiarpur and Ambala districts bear eloquent testimony to the havoc wrought by man and his cattle resulting in the denudation of enormous forest land in the hills, and devastation of thousands of acres of fertile cultivated land in the foothills and the plains below, as a result of accelerated run off and eventual high floods. The perilous consequences of deforestation and denudation are not localized only—but extend miles below, and may threaten roads, bridges, railways, dams and fields, because of furious and devastating floods. It is, therefore, not only the evil doer who suffers but the entire community. It is thus incumbent on the State not only to prevent the spread of this unfortunate evil, but also to devise ways and means to remedy the evil where it has already set in. As in all cases of constructive and remedial measures, the result of soil conservation and anti-erosion measures may be slow, though steady—as against the spectacular rate at which destruction may overtake the misdoings of man.

Attempts of any consequence in restoring eroded and denuded wasteland to their original fertility and protective utility must envisage full rest by way of complete closure to grazing, browsing, lopping, cutting, felling and firing as the first item on its programme. Complete closure is the panacea of all these ills. Closure helps the denuded land to reclothe itself with vegetation through stages of natural succession. Grasses, which are the hardiest by virtue of their minimum demands on moisture and soil-fertility, come in and gradually pave the way for the coming in of more exacting species of bushes by enriching the soil with organic matter by their leaf-fall and by increasing the moisture content through increased soil porosity. These low shrubs, in due course, lead to the recruitment of broad leaved species of a more exacting nature, through natural progression, and ultimately to a crop which is in stable equilibrium with the "locality factors" of the site—which in forestry we call "climax of the locality".

When once the 'protection' of the area is ensured—which means at least that half the job is done—we can help nature and expedite the results by artificial means. These methods, as practised in Hoshiarpur Forest Division aim at :—

(i) Reducing the velocity and extent of surface run off and hence sheet erosion,

(ii) Retention of maximum possible moisture in site,

(iii) Prevention of deepening of gullies and ravines, i.e., gully-erosion,

(iv) Restoration of vegetative cover.

The counter erosion measures consist of contour trenching in the catchment area where slopes are easy to moderate and check damming and gully plugging of ravines with rough dressed sandstone or live hedge material like bana (*Vitex negundo*), *Ipomea*, *japlota* (*Jatropha curcus*), *kaimbal* (*Lannea grandis*), *nara* (*Phragmits.*), *shisham* (*Dalbergia sissoo*) on the hills to reduce drainage velocity and scouring action. Sowing on the trenches and in the blanks with suitable species like *khair* (*Acacia catechu*), *kikar* (*A. arabica*), *phulahi* (*A. modesta*) and planting of *shisham*, bamboo, *tut*, *simal*, *siris* in suitable places along ravine banks and in the trenches in the catchment area to help restoration of vegetative cover and accelerate "progression" are done. Lower down in the *belas* also, sowings and plantings are done. Stream bank planting is done to consolidate banks and shelter belt planting of *shisham*, bamboo, *simal*, *siris*, etc., is done to protect the cultivated fields.

Sidh-Chalerh Village Forest.—Sidh-Chalehr village wasteland, situated between 2,000′ to 2,250′ elevation in Una tahsil of Hoshiarpur district was once clothed with rich *chil cum* scrub forests. Man, in his lust for money subjected it to the torture of ruthless hacking, uncontrolled grazing and browsing years ago, with the result that the major part of it was completely deforested and exposed to excessive soil wash and gullying. Excessive grazing trampled down the ground hard and rendered it unfit for seedling recruitment. Fires made matters worse and aggravated 'retrogression'. A part of the wasteland bears *chil* crop which is very open, malformed and stunted because of 'maltreatment' and fires. These were virtually tapped to death and the 'graves' they bear are adequate proof of it. The villagers consented for *chil-sal* closure over 472 acres for 15 years in 1941 under the provision of Section 38 of the Indian Forest Act, by virtue of which resin tapping of *chil*, and felling of *chil-sal* (actually there is no *sal* in this village) for purposes other than those of legitimate domestic requirements, were brought under the control of the Divisional Forest Officer. Exploitation, whenever permitted, was subject to rules of forest conservancy, as followed in the management of State Reserves. This saved the existing few survivals from total extinction. Later on, in 1945, 110 acres were brought under complete land closure—(under block A of Section 38 of Indian Forest Act—closure against lopping, grazing, browsing, breaking up of land and firing) and 156 acres were partially closed (under block B of Section 38 of Indian Forest Act) wherein only browsers were ousted. Part of the area now completely closed had already some *chil* regeneration of a bushy and stunted nature as the result of partial voluntary closure by villagers for 7–8 months in a year by way of maintaining 'grass preserves' ('*rakhs*' or '*kharetars*'), sometime before the enforcement of Section 38 land closure. These completely closed areas have responded remarkably to closure resulting in profuse regeneration of *chil* and other species like *Diospyros tomentosa* (*kinu*), *Cassia fistula* (*amaltas*), *Carissa spinarum* (*garna*), *Cœsaria tomentosa* (*chila*), *Woodfordia floribunda* (*kainth*), and so on on the northern slopes (see plate 3). The already existing stunted and bushy *chil* saplings are now establishing themselves and putting on magnificient leaders. The southern slopes, which are hot and dry, generally bore very little soil and were conspicuously bare even down to the parent rock, are now making marvellous recovery through recruitment of widespread grass and thorny bushes. Natural regeneration of *bhabar* (*Eulabiopsis binata*) and other valuable fodder grasses like '*lumb*' (*Heteropogon contortus*), *dhaul* (*Chrysopogon montanus*) are virtually invading the once unproductive, naked slopes on sites wherever there was a grain of soil to support these. Artificial means of counter erosion were commenced on a very small scale in 1946, where 2 ravines were plugged and stone dammed, an acre of trenchable slope was contour-trenched in scattered bits (the entire trenchable area is barely 6–7 acres). *Kikar* and *khair* were sown on 220 trenches in double lines—one on berms and the other on ridges—in 1946 rains. The results were encouraging, and both check-damming and trenching were extended in the following year. Another 200 trenches were sown—but this time mainly with *khair*—*kikar* being more frost tender was discouraged, and some failures of 1946 were resown. In 1948–49, 340 trenches were dug, which were sown with *chil* and *khair* in 1949. Some of the trenches of 1946 *kikar* sowings bear a crop of 12′–13′

high *kikar* poles, which are already flowering (see plate 1). A large number of 1946 and 1947 *khair* trenches bear excellent young saplings of *khair* crop—in some cases even 8′–9′ high, which have been properly cleaned and pruned (see plate 2). In 1948, the remaining 2 ravines were also check-dammed from top to bottom. Check-dams in all the ravines have silted up (see plate No. 5) and the ravine channels are now reduced to several series of almost level steps. Planting of *shisham, siris* and *ritha* has been done behind the silted up check-dams, and along ravine banks 1949 sowings of *chil* and *khair* are doing quite well and have been weeded. The remarkable effect of trenching (which, however, has been done on a modest scale so far) stands out most prominently—*viz.*, the interspaces between lines of trenches bear very dense grass growth—because of greater absorption and rententivity of moisture in the trenched area. Not only that—trenches have reduced the entire catchment into a series of smaller catchments, reduced run off and hence sheet erosin and have served as silt traps. Trenches are the most suitable sites for raising artificial crops from seed sowings on berms—most particularly on hotter solpes, where preservation of moisture is of paramount importance. Sowings of *chil, khair* and *kikar* were tried in 1947 and 1948 in small patches, also in the blanks, but the results are poor—indicating the advantage that worked up berms of trenches—'moisture traps'—offer to successful establishment of sowings. This closed area with vegetative cover presents marked contrast to the adjacent unclosed barren and rocky area of the same village on the one hand (see plate No. 4) and another contiguous flat area—equally devoid of vegetation, looking like a rolled play field—of another village. This serves as an eye opener as regards the efficacy of complete closure and anti-erosion measures like trenching, etc. The income from grass from about 65 acres of this closed area rose from Rs. 130/- in 1945 to Rs. 355/- in 1947, though it declined to Rs. 275/- in 1949, not due to reduction in grass yield but because of evacuation of muslims from the neighbouring area and the resultant fall in local demand. The grass yield from this area can safely be regarded to have risen 2½ to 3 times during the last 4 years. It may be too early to say, but it appears very probable that in a few years' time the area will get completely covered up with vegetation—grasses, bushes and small trees—and if adequately protected against grazing and firing, we shall again have a two storeyed forest in due course, with *chil* in the top storey and scrub in the lower storey.

EXTRACTS

FORESTERS FIGHT FIRES FROM HELICOPTER

(Austral News, Vol. II, No. 11, Nov. '49 p. 8)

Men, equipment lowered from hovering aircraft

TWO PASSENGERS RIDE OUTSIDE

Foresters borne by helicopter to fire outbreaks in otherwise inaccessible regions of the dense Australian Eucalyptus forests will be key men in the Victorian Forests Commission's 'catch-them-before-they-get-away' attack on the fire hazard.

Recent trials with a Sikorsky helicopter have been most successful.

In the past, Victoria has suffered great loss from destructive bushfires in summer months.

Fire fighting, already highly developed, will be taken a stage further with the use of helicopters to set down fire fighters and equipment at the seat of fire outbreaks.

Fire fighters cannot be parachuted into the Australian native forests. They would be trapped in the thick forest roof and injured by jagged branches.

FIRES TRAVEL FAST

Fires travel with such terrifying speed

PLATE I

1946 Trench sowings of *KIKAR*, Chalehr Sec. 38. Poles have attained a height of 12′.

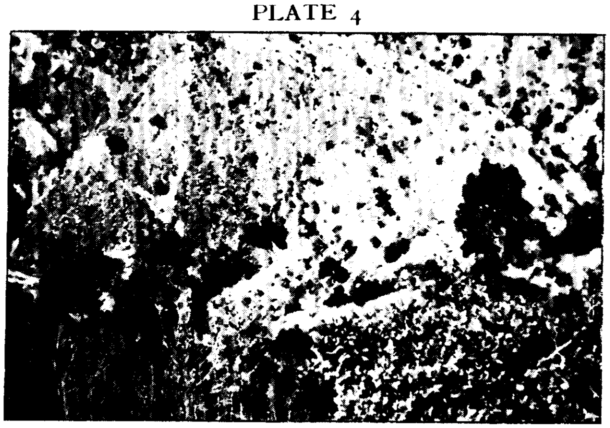
PLATE 2

1947 Trench sowings of *KHAIR*, Chalehr Sec. 38. Saplings grow taller than the tallest of Bharwain Range Foresters. The lines have been cleaned and saplings pruned. *Baib* and other fodder grasses have completely covered the area in the background.

PLATE 3

Profuse regeneration of young *chil* and establishment of the already existing sapling crop in Sidh Chalehr—Sec. 38.—Northern aspect—result of marvellous response to closure enforced since April, 1949.

PLATE 4



Sidh Chalehr—Marked contrast between the well vegetated N.W. slope of the closed area (nearer to the camera) and the almost naked S.E. slope of the unprotected area (farther end).

PLATE 5

A completely silted up check dam in Sidh Chalehr Sec. 38. Dense grass grows all round the closed area.

Photos. Author.

through these forests in midsummer that the risk of isolated fire-fighter's being caught by the flames would be high.

Foresters in each Victorian forestry district are now being given familiarization flights before the onset of the summer danger period.

Helicopter trials not only tested the possibilities of the machine under local conditions, but also served to map-spot cleared patches for future landings, and to give foresters experience in landing from the machine.

CARRY EQUIPMENT

Each trip, the Sikorsky helicopter carried the pilot and three passengers, a pump unit, ten hose lengths, radio, food and water, axes and rake.

The foresters and their equipment were let down in harness by a winch while the machine hovered at around 50 ft. and were hauled up again in the same way.

But where possible the machine landed, or went down near to ground level and allowed the men to step down to earth.

The difficulty of keeping the machine steady for very long is one reason they dislike hovering over the forest roof and lowering men through the trees. Foresters would be swung around so much that they would be thrown against the trees and injured.

'DECK PASSENGERS'

Although the Sikorsky only has room for three passengers and the pilot inside, they sometimes carried five passengers. The other two rode sitting on the broad under-carriage struts. This is the first time passengers have been lifted by helicopter in this unorthodox way.

BICICLETTA ROBUSTA

(*WOOD*, October, 1949, page 291)

So much effort has been expended during recent years on the search for timber substitutes that it is something more than refreshing to learn, via our recreational contemporary "Cycling", of a recent reversal of the trend. This is no less than a wood-framed bicycle. For many years a well-known Italian maker had toyed with the idea of building a machine of laminated wood, and when steel supplies became short during the war, he began serious work on the idea and produced a design that proved to be thoroughly practicable. The main frame consists of a continuous length of laminated ash and beech, shaped and bent to form the forked seat stays, cross-bar, head and down 'tube', at the bottom of which it broadens to allow the . bolting the bottom bracket dividing into a fork again for the chain stays. The seat tube, which is of laminated beech double-butted, and the seat pillar are the only round parts of the frame. The ends of the laminated forks back and front are pegged into alloy castings. The head assembly, which is of nickel chrome steel, passes through the top and down tubes, giving extra rigidity to the frame. Handle-bars also are laminated and mudguards are of beech. Wood-frame wheels are, of course, a standard fitting for light-weight machines. The Vianzone laminated wood bicycle is finding a widening circle of riders, who say that it reduces fatigue to the minimum because of its light weight (12½ lb. fully equipped) and general resilience. The machine has undergone exhaustive road tests in Italy and those who are acquainted with the present condition of the Italian roads will appreciate how severe the tests were. The correspondent of "Cycling", who tried the machine out in this country reported that "I found the machine very responsive and lively, handling well at all speeds and on all conditions of road surface. It was possible to crash into the worst pot-holes at speed with no discomfort, the frame and springy handlebars absorbing all jarring and buffeting". The wood-frame bicycle is not, of course, a new idea—it is, in fact, a very old one. Early models often had solid wood-frames and there was a type that had a frame of bamboo tubes. But these are hardly comparable with the streamlined Vianzone, which its designer succulently describes as "bicicletta robusta, elegante, elastica, silenziosa"

GUM FROM THE 'GUM TREES' HAS COMMERCIAL VALUE

(Austral News, Vol. 11, No. 12)

Eucalyptus kinos have lately been the subject of research by the wood chemistry section of the Forests Products Division of the Commonwealth Scientific and Industrial Research Organization in Australia.

These kinos are resinous exudations and accretions containing tannin and are more familiarly known as the gum which exudes from the local Eucalyptus tree.

The explorer William Dampier noted in 1865 that "gum distills from the knots or cracks in the bodies of the trees. We compared it with some gum dragon or dragon's blood that was on board, and it was of the same colour and taste".

It is possible that the various Australian kinos may contain in concentrated form the phenolic compounds which normally exist in the wood in small quantities.

Function and purpose of kinos in the wood are not at present known. It is thought that the kino veins and pockets are pathological phenomena, developing as a result of injury to the tree.

One practical utilization by the Division was the extraction of tannin from the kino-impregnated bark of Eucalyptus calophylla.

At the present there is a world shortage of vegetable tannin and the Western Australian jarrah is considered a likely species if the experimental work on the kinos is successful.

Officers of the Forests Products Division believe that if the kinos are found to contain the phenolic compounds they may be put to commercial uses.

Overseas countries, particularly Sweden, have discovered several phenolic compounds in the heart wood of their genera. Components from spruce and hemlock can be readily converted to very efficient anti-oxidants for fats and oils.

AUSTRALIAN RESEARCH IS HIGHLY PRAISED

(Austral News, Vol. 11, No. 12)

Biological weed control succeeds

Australia leads the world in biological control of weeds, according to Professor H. Smith, officer in charge of biological control of insect pests and weeds at Riverside, California.

Professor Smith who recently visited Australia instanced the weed St. John's Wort which has now been successfully controlled.

St. John's Wort, once credited with almost magical healing properties when used in the preparation of salves, was introduced to Australia in the gold-rush days of 1870. Before long it had escaped from cultivation and spread to many parts of the country.

By 1920, the weed had complete control of some 750,000 acres of good fertile land and there seemed to be no method of eradicating it.

Besides smothering crops, the weed has a toxic effect on animals that graze on it. Cattle become photo-sensitive and in places where they are lightly pigmented, the sun causes skin disease, while contact with water brings on attacks of paralysis.

With sheep, the toxic juices of the plant set up sensitive skin spots, causing itchy spots which the animals rub until woll is damaged and bodies are injured.

After initial research work had been done by Australian scientists at Farnham Royal, in Buckinghamshire, England, it was decided to experiment with the liberation in Australia of a small oval beetle, *Chrysomela hyperici*, which would feed only on St. John's Wort.

In 1939, two more beetles were enlisted in the war on the weed. They were *Chrysomela gemellata* and *Agrilus hyperici*.

These beetles have slow breeding habits, producing only one generation a year, and they work slowly in their attack on St. John's Wort—infested areas; so it took nearly 10 years for their value to be assessed.

By 1949, however, when thousands of acres that had been a waist-high wilderness of weeds were again under cultivation the success of the experimen t was definitely established.

SOIL CONSERVATION HELP PLANNED

(Austral News, Vol. 11, No. 12, December 1949, p. 6)

Includes Loans for Works

A programme of erosion control, with assistance to landowners in the undertaking of conservation works, has been devised by the Minister for Conservation in New South Wales.

Under Law, the Minister may grant monetary and technical assistance to farmers and graziers.

A LANDHOLDER may in the first instance apply for inspection of his property and advice.

This service is given free of charge.

Soil remedial measures may be taken which do not require construction of works, such as contour ploughing, resting of paddocks, strip cropping, rabbit control or changed land use.

Officers of the Department of Agriculture will assist in devising farm programmes involving changed land use, if need be.

If construction of work is considered necessary by the landowner after discussion with the Soil Conservationist, then he may obtain financial assistance, in some cases up to 100 per cent. of the cost of works. The amount must be repaid with interest over a term not exceeding fifteen years.

CAN SHARE

Special provision is made for advances to two or more landholders, to enable holders of adjoining properties, to co-operate in a joint scheme. The participants in such a scheme themselves apportion the costs but they are not required to accept financial responsibility for their partners in the scheme.

Construction of works for which financial assistance can be obtained may include the establishment of grassed waterways, contour furrowing, graded banks, pasture improvement and small water storages to reduce excess run-off of water.

The landholder himself may undertake to do this work, hiring, if necessary, available machinery from the Soil Conservation Service. Such machinery includes tractors, bull-dozers and graders (with which Departmental operators may be hired) and other plant such as road ploughs available without operators.

Landholders may, on the other hand, employ a contractor to do the work for him. The contractor may be a private individual or firm or local government body or rural co-operative society.

Again, the landholder might prefer that the Soil Conservation Service carry out this work for him.

> Interesting advances are being made in the construction and design of conveyor belts. Woven wire belts are now being made extensively in Australia.
>
> These enable materials to be treated whilst they are in movement, and loads can be safely carried through washes, sprays or baths. The belts can be manufactured of metals which enable them to withstand most effectively atmospheric and chemical corrosion. Special types of wire belts are now being made for the particular needs of industry, by one of the largest Australian manufactures.

If he requires merely the preparation of designs and estimates of cost of works, or supervision of works on his lands, the Department of Conservation will undertake this for him and notify him of the cost, if any.

The Minister for Conservation will authorize advances only in cases where his officers are satisfied that the works are necessary and have a reasonable chance of success.

The Rural Bank of New South Wales will be acting as the agent on behalf of the Government in making the advances and in collecting the repayments.

WE MUST GROW TREES

BY SIR SHANE LESLIE, BART.

('Trees and The New Earth', Vol. XIII, No. 2)

A summer School for forestry in these times is not merely a way of passing a holiday—or a break in the routine of more important National Service. It has become a necessity, a priority, a social salvation and even so it seems difficult to find the phrase for anything so important as the Tree Service in England to-day.

The world has begun to awaken to the immense importance of Forestry as a science and a factor in human life.

Man was originally a forest-animal and lived in the aboriginal Forest which is symbolically called 'The Garden of Eden'.

We realize that countries which have cut their forests have often cut off their future. The happiest and most contented peoples are those who have kept their forests : Switzerland, Scandinavia and, until war harried them, Finland and the German Black Forest.

Where timber has been cut disasters of some sort have always followed. The United States has developed dustbowls. Greece, Italy, Balkans, Palestine have all suffered grievously in erosion, diminution of crops and arable land. Spain has hurt herself most of all and to-day in the sixth year of a drought must be wondering what offence Nature has taken in the past. Great forests could have allayed the biting winds, the burning heats, the fierce floods—the loss of soil.

And we look to England's case with a developing population—every now and again an extra million is signalled to the food and educational authorities. Yet the acreage suitable for food is decreasing. Cemeteries, trunk-roads and dormitory towns are extending and extending. No great city is shrinking. Every acre of country not used for garden or pasture or crops should be tried out for trees which will grow amongst rocks and in sands.

We are in sight of a terrible timber famine—in ten, fifteen or twenty years. Meantime fires, axes and neglect are lessening all timber supplies everywhere.

Scotland has taken a lead which can be commended to all. Wales has the greatest potentialities, and the day might return for her villages choked by mining to return to the green of the forest. Ireland is one of Europe's treeless countries but has awakened to her peril. The loss of her trees has singularly constricted the amount of her scenery.

There is planting for ornament, for vista and scenery, planting for game, planting for commerce and planting for a bank balance. There is no more sure and steady investment than planting trees. Put in three pennies and sixpennies, you can cut them down as pounds—and make a girl's dowry. How much timber capital would be growing in this country if a tenth of the money lost in wild-cat schemes abroad had been put into private woods and national forests financed by big companies.

I ask if England's whole weather pattern could not be improved by a big Forest area running across the North Country. Is it rash to assume that when the Caledonian Forest covered North Britain, the luxurious Romans made the South into their Riviera ? One cannot imagine Italians coming to Brighton or Torquay to-day for their holidays. But the British climate under the Downs with St. Leonards Forest stretching across Sussex must have been a delicious one.

Let us build up forests instead of cemeteries. Instead of acres of foreign white marble in poor taste let us plant acres of young saplings—to every friend and relative a tree with a plaque. Those trees will outlive all tombstones that encumber the land. Men of the Trees, when dead, will wish their spirits to move amongst trees not the ghastly congestions of Necropoly.

How well the above is applicable to the vast treeless plains of the Indian sub-continent to-day.

[*Editor.*

SIX MONTHS AFTER MYSORE

BY DR. M. A. HUBERMAN

(*Chief, Forestry and Forest Products Working Group for Asia and the Pacific*)

Foresters in India, through their representation by their Inspector-General of Forests, President, Forest Research Institute and Provincial Chief Conservators at the Forestry and Timber Utilization Conference for Asia and the Pacific, held at Mysore in March–April 1949, already know that a Working Group has been set up in FAO's Regional Office in Bangkok to help Governments carry out their unanimously adopted resolutions on forestry and forest products. Now just what does this Working Group actually do ? Perhaps the best way to answer this question is to describe briefly the Group's activities since it was organized.

First of all was the job of notifying heads of forestry services, Ministers of Agriculture, and other policy-making administrative officers of governments in the Region of the existence of the Group, thereby initiating lines of communication for all future work. Contacts had to be made with officials of other international organizations such as ECAFE and its Flood Control Bureau, UNESCO, International Meteorological Organization, and the Pacific Science Congress Committee on Forestry, and with business organizations, scientific societies and newspaper and radio people, to develop co-operative relations on specific projects. Through correspondence and personal visits with these officials and agencies, opportunity was taken to direct their attention to the importance of forestry in each country and in the Region as a whole. Copies of the Mysore Conference report were made available to all individuals who were considered to be in positions to influence forestry and forest products activities in their governments. Reception accorded to the FAO staff was, in practically every case, most cordial and gave promise of profitable future relations. Such contact work, while it is time consuming and unexciting, is not at all unpleasant and is really very informative owing to the variety of personalities and interests one encounters. The state of knowledge of such individuals on forestry matters is surprising, and on the whole very encouraging to a forester seeking to "spread the gospel" of conservation. It is worth trying on your own local officials, not only in governments but also in businessmen's organizations, professional, labour, and religious groups, and technical people at schools and research stations. The experience is worth the effort.

Then came the more mundane tasks of housekeeping, such as setting up filing schemes, arranging office procedures, complying with headquarters regulations regarding correspondence, budgeting and expenditures and administrative reporting, and through it all, seeking to keep to a minimum the irksome "red tape", a fight which needs to be fought constantly in all organizations of any size. The Group is grateful that Mr. William Cummings, in charge of the Regional Office for FAO operates on the same principle as most foresters, namely, administrative office procedures are only the *means* of getting the technical job done, and are not *ends* in themselves. This attitude has saved considerable time for the forestry staff, leaving it freer to get on with its job.

Once the machinery was set up, it was possible to begin providing services in answer to specific requests. A few examples of such requests may be of interest.

Two forestry students from Thailand, a Technician from Burma and a forestry official from Thailand were preparing for study and travel in Europe and in the United States. Suggestions were made as to people worth seeing, projects to be visited and schools, research Institutions and industrial establishments worth visiting. When agreement had been reached on these suggestions letters were sent to appropriate individuals to facilitate the travel and to plan detailed itineraries for the visitors.

Related to this service, was the planned solicitation for financial assistance for forestry scholarships. A number of commercial Timber Organizations have been approached for contributions for setting up such forestry scholarships, but unfortunately, no encouraging results have yet been obtained. Efforts will be continued in this direction, however, pointing out the immediate benefits in terms of

goodwill for the commercial organizations as well as the long time benefits to the wood-using industries in the country, and to the calibre of forestry administration in the future.

One country, in the process of negotiating with the World Bank for a loan for the construction of a Plywood Factory, asked for help in connection with preparation of the specific information required and for advice to the World Bank Representative when the time came, for actual inspection of timber supplies in the forest. This same Government has asked for locating forest management technicians for work in enumerations and preparation of long term management plans.

Requests have also been received from several countries on such specific problems as methods of log-transport in difficult terrain, control of *Lantana camara*, and for methods of making enumerations and growth studies in *Dipterocarps*. In each instance, the Working Group was able, through correspondence with countries having experience in solving these problems, to supply an answer to the enquiring governments.

By way of carrying out the resolutions of the Mysore Conference on exchange of information, a tentative list of references on forestry in Asia and the Pacific was prepared and submitted to Heads of Forestry Services, Forest Research Institutes, and Forestry Schools, asking each to prepare as complete a list as possible of all forestry publications and journal articles up to the end of 1949. When all of this information has been received, a forestry and forest products bibliography can then be put together for the use of foresters in the region and can thus serve as a starting point for exchange of specific publications. Such a bibliography can also have two other beneficial effects : the first is by providing a basis for assessing forestry and forest products research to date to reveal gaps in knowledge that still remain to be filled, thereby serving as a guide to modifying future research programmes. The second benefit of such a bibliography is that it will help to co-ordinate the work of literature classification with that of forestry in other parts of the world as illustrated by a recent revision of the Oxford classification which has been sent to governments in the region. Such a classification can also help in the organization of research projects as was suggested by the staff at the Forest Research Institute at Kepong, Malaya.

In order to help foresters obtain the proper recognition of the forest resources and of their work, reproductions were made of the fine forest map of the Philippine Islands giving the forest types, the areas by land use, estimates of volume of standing timber, the organization charts of the Philippine Bureau of Forestry, and the location of sawmills and other wood-using installations. This map and chart was sent to heads of forestry services in the region with the suggestion that they consider the possibility of preparing similar material for their own country in order to present in very concise form the principal element in the forestry and forest products picture to acquaint cabinet officers or other policy-making officials with their situation as a basis for increased budgets. Some of the countries already have prepared such material in one form or another, but the interest in this map has been very encouraging in every case.

In seeking to carry out the recommendations of the Mysore Conference with regard to the calling of a meeting on standardization of lumber grades, nomenclature and timber testing methods, interviews were had with forestry officials in several countries for advice on the place and time, and on demonstration facilities, which would best accomplish the objectives of such a meeting and would best meet the needs of countries faced with these problems. It was very encouraging to see evidences of increasing interest in the question of lumber grading especially in those countries seeking to build up their valuable export trade. It was also heartening to learn that progressive lumber producers and exporters are more and more becoming convinced of the benefits of standardized grading.

In this connection, several countries have followed up the recommendation of the Mysore Conference with regard to activities in trade promotion in consuming countries. At least four countries represented at the Mysore Meeting have told of making arrangements for local trade representatives or have sent individuals to obtain new buyers for their timber products. Plans are being made to take advantage of various Expositions and Industrial Fairs to display the timbers available for export by several countries. This cannot help but increase trade in forest products.

Most foresters have already heard about the Technical Assistance Programme, more commonly known as the Point Four Programme, to provide aid principally in the form of Technicians to countries seeking to develop their natural resources. As has been pointed out many times, those countries which have projects already under way such as road-building to open up timber areas, nursery and plantation development, modernization of logging and sawmilling operations, the taking of forest inventories perhaps with the use of aerial surveys, the development of watershed protection, and flood control programmes, the setting up of fire-protection systems and many other specific activities will have the best chance of getting highest priority consideration for technicians to help in such work. The Working Group at Bangkok has therefore been urging governments to translate their development plans into specific activities and to get them in operation, even if only on a small scale, as quickly as possible.

In anticipation of the setting up of the Point Four Programme, the Bangkok Office has begun to build a directory of foresters for the region as a basis for a list from which countries could select technicians for such assignments. A large number of individual cards are already on file giving the name, title and country of each forester. It would be helpful if the forestry service of every country would prepare such a complete list of their technically trained foresters, the position they hold, the training they have received, and their speciality such as forest engineering, reforestation, soil conservation, inventory and aerial survey methods, lumber grading, timber testing, statistical analysis or others which would be useful in the Point Four Programme. If and when this programme materializes there should be many opportunities for short term assignments in other countries which would of course be beneficial not only to the country receiving this assistance, but to the forester taking such an assignment, through increasing his experience.

Another means of providing information for the directory of foresters mentioned above would be through professional societies of foresters in each country where they exist. Where such societies have not yet been organized, the Working Group at Bangkok has sought to develop interest in such organizations. In many countries such professional societies of foresters have been instrumental in crystalizing forestry opinion and thereby bringing their influence to bear on important forest policy decisions of their governments. It should also be obvious that such societies can help improve the prestige of foresters and promote recognition of the importance of forest resources and forestry work.

Most foresters have read UNASYLVA the Journal of the Forestry and Forest Products Division of FAO. In order to increase its readers' interest, the delegates at Mysore suggested the appointment of country correspondents to provide the Editorial staff with current news items. In this connection, the Editor of UNASYLVA is anxious to obtain suggestions from readers for the improvement of the Journal. The Working Group at Bangkok will be glad to receive such suggestions and forward them to the Editor.

How many foresters have seen the FAO forestry film "GREEN GOLD"? It tells the foresters story effectively and interestingly and is well worth the time not only of non-foresters but of technical foresters themselves. If you have not yet seen it, arrangements can be made for the loan of this 16 mm. sound picture through the Working Group at Bangkok. This film has already been shown to large audiences in India and Thailand, in some cases in the commercial theatres. People who have seen the picture agree that the Information Divisions of FAO and of U.N. at Lake Success deserve congratulations for a job well done.

Another interesting phase of the work of the Regional Office staff is the opportunity of getting acquainted with foresters themselves, by visiting with them logging operations, sawmills, and wood-using installations, research institutes and schools as was done recently on trips to southern Thailand, Malaya, Sarawak, North Borneo and Burma. Advantage is always taken in the course of these visits not only to learn of the specific problems facing administrative and research men, and seeking to translate these into specific services, but also to meet government and local administrators to impress upon them the importance of the forest resources within their jurisdiction as well as the assistance of forestry talents on their staffs.

If space permitted it would be of interest to describe recent visits by the Working Group to Southern Thailand, Malaya, Sarawak, North Borneo and Burma. Perhaps readers will tolerate very brief summaries of these visits.

In Southern Thailand the District Forest Officer and his staff conducted me through his small forest nursery, *Casuarina equisetifolia* plantations on difficult beach sand sites, a jelutong factory, an elephant logging operation in mixed *Dipterocarpus* sp. forest, and several not very modern sawmills. In the dripping forest, leeches were thick, and before we were able to disengage them from our legs they were temporarily much thicker, with blood. Among the chief problems here are the need for budgetary support for larger trained forestry staff to cope with the jobs of forest management and supervision of logging by private concessionaries on government forest reserves; and a more adequate supply of skilled labour through improved housing and malaria control.

In Malaya brief discussions were held with State Forest Officers, Research Officers at Kepong and Sentul, the administrative officers at Kuala Lumpur and the Forest Officer at Singapore regarding a wide variety of subjects. These ranged from silvicultural operations during current unsettled conditions, research programme development, techniques and terminology, exchange of publications, bibliographies and forest literature classification, to locating sawmill equipment that may be for sale, suggestions for the 1950 meeting on standardization of lumber grading, timber testing, and nomenclature, and facilities for demonstrating grading and timber testing methods, and progress of forest road development schemes. The principal problem here is to achieve settled conditions, which will permit the forestry staff to get on with the clearly conceived job of work, so it may continue to serve as guides for forestry activities in neighbouring countries. The development and growing application of the Malayan Export Grading Rules deserve special commendation, and should be studied carefully by all who are concerned with production and export of lumber in this Region.

In Sarawak the Conservator of Forests showed me swamp forests, efforts to reclaim by reforesting peaty forest land which had been cleared unwisely for pineapples, successful plantation of *Casuarina sumatrana* and *C. equisetifolia*, tree poisoning to favour *belian* (*Eusideroxylon zwageri*), jelutong (*Dyera lowii*) plantings, and cleaning operations in mixed Dipterocarps to form natural nurseries ("Cold storage" in the words of the Conservator, although "cold" was hardly appropriate when sweat was dripping from my nose and soaking my shirt and shorts) to supply seedlings for later transplanting. Of special interest was the visit to the Agricultural Experiment Station at Tarat, where methods of controlling lalang, *Imperata* grass, by heavy shade of planted trees, by mechanical cultivation, by competition from fast growing legumes, and by regulated grazing, have been developed to the point of practical application.

The close collaboration between the Conservator of Forests and the Director of Agriculture in this phase of controlling shifting cultivation deserves high praise as a pattern to be used in other countries as well. Similarly the addition of elementary forestry in the course at Batu Lintang for training field staff men in Agriculture and Forestry is a worthy example of joint effort. But the outstanding problem in Sarawak Forestry work is the shortage of staff, which is preventing the Conservator from going ahead with such worthwhile work as forest demarcation and acquisition, forest management, enumeration surveys based on aerial photographs, and silvicultural improvement of existing reserves, construction of extraction routes, advisory services for improvement of private sawmills, and initiation of lumber grading. Fortunately, the Conservator has the complete sympathy of the Colonial Secretary in trying to increase the staff of the Forestry Department.

In North Borneo one was struck by the remarkable recovery of the forest industries since the War, especially in production of lumber for local reconstruction and for export, and production of cutch, a valuable dollar earner. Much more progress could be made in sound exploitation of high quality logs, if an early settlement could be reached in the Chartered British Borneo Timber Co. case. Delay in the settlement of this case is holding up the logical development of logging operations of other private companies anxious and ready to begin extraction and conversion of Borneo's valuable forests into logs and lumber for export to bring in foreign exchange which is so badly needed at this time. Visits were

made to a narrow-gauge railroad logging operation up the Segaliud River, and to the 3 principal sawmills and the cutch factory in Sandakan. I watched scaling of logs and grading of lumber according to Rules developed by the Forestry Department. Discussions were held with the forest officer and with government development officers at Jesselton regarding shifting cultivation which is so serious on the west side of North Borneo. The work of forest map making and timber survey based on aerial photographs was explained by the Assistant Conservator. One was especially impressed with the essential role played in the total economy of North Borneo by the proper use and expansion of sound exploitation of the forest resources, and the fact that this was largely the result of the outstanding leadership of the Conservator of Forests in the whole scheme of government activity. Seldom have I seen a country where the head of the forestry department was so intimately, and effectively, involved in so many aspects of public service. The forestry profession can well be proud of the example thus set by H. G. Keith. One cannot help but tell foresters elsewhere, "GO THOU AND DO LIKEWISE".

The brief visit to Burma provided an opportunity to discuss the activities of the Forest Service and of the State Timber Board and to note how their efforts towards productive work are being hampered by unsettled conditions in the country. By contrast the work of the Government Timber Depot near Rangoon is proceeding nicely in development of dry-kiln schedules, and in new uses of Burmese wood products by the modern well-equipped workshop. Information was given to the Chief Conservator regarding the needs of neighbouring countries for recruiting trained foresters, and suggested that perhaps some Burmese foresters would be interested in short term employment outside Burma. He promised to circularize his staff regarding these opportunities. It was interesting to learn that in the effort to reinstitute forestry training at Rangoon University for professional level education, the headquarters staff is to do the major share of the teaching. The Ranger School at Pyinmana has not yet reopened.

The various obstacles to expanded forestry and forest products work, as noted on the visits to the countries mentioned, as well as other problems elsewhere in the Region, can be discussed profitably during the 1950 meeting of the Forestry and Forest Products Commission for Asia and the Pacific. Perhaps, together, the foresters of all Asia can help support the recommendations of the Heads of individual forestry services for overcoming these obstacles.

Finally, you should remember that the Working Group in Bangkok has been set up to serve the foresters in the Region. Therefore, requests for assistance are invited. The Working Group will try its best to meet those requests. The address is Chief, Forestry and Forest Products Working Group, Food and Agriculture Organization of the United Nations, Maliwan Mansion, Phra Atit Road, Bangkok, Thailand. Let's hear from you.

SELECTION OF SILVICULTURAL TECHNIQUES

Principles governing selection of silvicultural systems suitable to given forest conditions and management objectives, and establishment of suitable forest research programmes, including provision for statistical analysis

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ABSTRACT

As a reflex of the continental range of climatic conditions prevailing in India, the forests in the country exhibit a corresponding diversity of types. While extensive coniferous forests occur on the Himalayas and tropical evergreen forests in wet localities, the mass of India's forests belongs to the tropical deciduous type characterized by a great wealth of species, of which only a few are valuable.

The sal forests of Northern India are an important exception in that the species occurs gregariously as the climax dominant over extensive tracts.

High forest systems of natural regeneration have been successful only in the coniferous forests on the Himalayas and in sal forests where advance growth is already present in quantity.

It has not been found possible to rely on natural reproduction for restocking gaps left after selection fellings in mixed forests. The effect of such fellings is in general to increase the proportion of valueless species at the expense of the valuable ones. This applies in particular to teak forests, where the species occurs in mixture with other less valuable or useless species. The problem of regenerating such forests has been solved by making compensatory plantations of the selected species in suitable sites in the forest.

Our fuel forests are worked under the Coppice System but repeated working has been found to lead to reduced density of the crop and to lower yields. This effect has had to be countered by special measures of artificial regeneration.

For these various reasons India has had to develop special techniques of artificial regeneration of which the most significant are (1) the controlled use of fire in regeneration areas, (2) the *rab* method, (3) Taungya method and (4) the method of stump planting. A brief descripion of these methods is given.

New developments in the utilization of timber and the programme of afforestation which has been decided on in the country for increasing our timber and firewood potential and for securing a more balanced distribution of forests will alike call for research aiming at advances and modifications in our silvicultural techniques to meet new requirements. The importance of statistical control of silvicultural research has been realized in India and progressive steps have been taken during the last two decades at the Forest Research Institute for securing such control.

Silvicultural Systems.—Troup defines a silvicultural system as "the process by which crops constituting a forest are tended, removed and replaced by new crops, resulting in the production of woods of a distinctive form". The silvicultural system adopted must be based on two broad sets of considerations, namely, technical considerations and management considerations. Technical considerations relate to such matters as the composition of the crop, the silviculture of the component species, the ease or difficulty with which the desired species may be regenerated in the local conditions, the dangers, physical or biotic, which threaten the young crops, the degree of tending required, the attainment of "normality" in the forests, etc. Management considerations are essentially of an economic nature and are concerned with the production of sustained (annual) yields, the quick production of the class of material required by the market, the development of markets for intermediate yields and the organization of methods of transport and sale of the produce.

Indian Forest Types.—A general appreciation of forest conditions in India is essential

for a proper understanding of the silvicultural techniques adopted in this country. India stretches between 70° and 92° E. longitudes and between 8° and 36° N. latitudes. Although a considerable part of the country lies to the north of the Tropic of Cancer, the general climate is tropical, with monsoon rains ranging from virtually nothing to over 500 inches. The main mass of the natural vegetation is mixed tropical deciduous forest, tailing off into scrub and thorn forest where the rainfall is deficient. In regions of high rainfall as in Assam and the Western Ghats climax vegetation is tropical evergreen forest. Coniferous forests divisible into sub-tropical, temperate and alpine types occur on the Himalayas, while the high plateaux of the Nilgiri and Palni hills in the south carry a characteristic form of stunted broad-leaved evergreen forest patches of which occur interspersed in extensive grasslands, the precise ecological status of which is a matter of controversy. Champion has broadly classified the chief forest types as follows :

I. Moist tropical forests (including the tropical wet evergreen and the tropical moist deciduous forests).

II. Dry tropical forests.

III. (Montane) sub-tropical forests including the sub-tropical Himalayan pine forests.

IV. (Montane) temperate forests including the low evergreen forests of the Nilgiri and Palni hills and the oak-coniferous forests of the Himalayas, which latter comprise the following associations :

Pinus longifolia—Quercus incana ;
Cedrus deodara—Quercus dilatata ;
Picea morinda—Abies pindrow—Quercus semecarpifolia.

V. Alpine forest and scrub.

Except for the pine and deodar forests of the Himalayas, the commercially valuable timber forests of the country all belong to the Moist tropical type and comprise the Dipterocarpus, *sal* and teak forests.

Floristic Richness of Tropical Forests.—Leaving the higher hills out of account, timber forests are as a rule found in regions with an annual rainfall of 40 inches or more and attain luxuriance where the rainfall exceeds 80 inches. Maximum temperatures are well above 100° F in the shade, and the excessive heat of summer is mitigated by the onset of the south-west monsoon which lasts from June–July to August–September and which is the principal source of rain in most of the timber bearing forests of India. The warm moist conditions favour the growth of a great wealth of species of trees, shrubs and herbs. Bamboos are a common associate in the moister forests, while grass occurs over extensive parts of the drier forests, and in many of the moist forests as a result of frequent fires. Our tropical forests are thus composed of a mixture of species, some of which are very valuable and economically exploitable at a profit while some others may barely repay the cost of exploitation ; a great many of the component species have under present conditions no value at all and are regarded as rubbish and often burnt or left to rot in the forest. Our most valuable timber tree, teak (*Tectona grandis*) occurs in mixed forests and under conditions where it grows well it often forms no more than 10 per cent of the crop of which only two or three others species (*Lagerstroemia lanceolata, Terminalia paniculata, Dalbergia latifolia*), which themselves constitute a similar small proportion, of the crop, may be marketable. Teak tends to form purer forests under drier conditions in Madras, Bombay and the Central Provinces, and where forest fires are of frequent occurrence it tends to oust less hardy species.

Gregarious Species.—While mixed forests are the general rule in tropical India, pure forests or forests where a single species occurs gregariously are often encountered. Such gregariousness is often the result of a special edaphic condition, such as excessive salinity or alkalinity of the soil, or of a recurrent biotic factor such as annual burning or excessive grazing ; or it may be due to some extreme climatic factor such as extreme drought or heavy frosts. Thus the purity of a considerable part of the *Chir* pine belt along the lower hills of the Western Himalayas is mainly due to the special ability of that species to survive fires. The degradation of mixed dry forests to open crops of one or two thorny species is often the result of heavy goat browsing. Gregarious patches of *Hardwickia binata* in Southern India owe their origin to its power of withstanding severe fires in dry eroded soils. The coastal mangrove forests are an adaptation to

tidal conditions. The relative purity of the *Dalbergia sissoo* and *Acacia catechu* forests in the riverain succession in the Gangetic plains is due to the comparative immaturity of the newly deposited alluvial soil.

Sal Forests.—The only climax species which occurs gregariously in extensive forests over a wide area is sal (*Shorea robusta*). Sal forests form a belt at the foot of the Himalayas from the Sutlej in East Punjab to the Brahmaputra in Assam and extend southwards into the Central Provinces and Orissa. There is little doubt that over the entire Gangetic valley comprising the United Provinces, Bihar and Bengal, and in Assam and a considerable part of northern Central Provinces as well as in Orissa, sal is the climax dominant, except where the conditions are locally either too wet or too dry for it. Over most of its range the sal is more or less pure, its proportion in the crop ranging from about 50 to 90 per cent. Experience has, however, shown that in many cases, notably in Bengal, the present high degree of purity of the sal forests is the result of regular burning in the past, which led to the elimination of other species less hardy to fire than the sal. Fire protection during the past fifty years has led to the reappearance of many evergreen species in many tracts. Sal is a deep rooted species which taps the lower layers of the soil and leaves sufficient moisture in the upper layers to support a subordinate storey of trees and shrubs (*Mallotus philippinensis, Sterculia villosa, Ougeinia dalbergioides, Lannea grandis, Clerodendron infortunatum,* etc.). Thus the purity of the sal forest, even when it is apparently 100 per cent, relates only to the top storey ; there are always subordinate layers of woody vegetation. This is a point of importance in the natural regeneration of sal. The sal seedlings have not only to push through the shade of miscellaneous shrubs and small trees, but have also to compete with their seedlings for the limited light and nutrients available. Sal saplings are heavily browsed down by animals of the deer tribe as soon as they show up above the protecting shrubs. Natural regeneration of sal in the sub-Himalayan *bhabar* tracts dies back for many years before the root stocks are strong enough to send up tall woody shoots. It is unnecessary to detail the numerous difficulties that beset the production and establishment of sal regeneration. Enough has been said to indicate that despite the gregarious nature of the species, we have not yet succeeded in solving the problem of *de novo* natural regeneration of sal, although a great deal of research has been devoted to it. The difficulties of natural reproduction of sal are so great in certain localities that they have given room for doubt whether the sal forest could be the climax forest in those regions after all and whether its apparent dominance over extensive tracts has not been substantially assisted by biotic factors, chiefly fire.

Application of European Silvicultural Systems in India.—The foundations of scientific forestry in India were laid by two eminent German forest officers, Brandis and Schlich, and for many decades our silvicultural techniques were adaptations of continental methods and principles of forestry. These consisted in rigid protection involving the complete exclusion of goat browsing, prevention and suppression of fires, strict regulation of grazing and control of petty illicit fellings as well as in the gradual introduction of European silvicultural systems with a strong preference for systems of natural regeneration. The principles of protection were perfectly sound and helped to rehabilitate speedily a degraded forest estate, although the application of rigid fire protection has produced unexpected results in many cases by inhibiting the regeneration of valuable species. We now have a better understanding of the role of controlled fire in tropical forestry and do not hesitate to use it in our regeneration techniques. This subject will be reverted to in a later paragraph. The attempt to apply European silvicultural systems of natural regeneration to Indian high forests has on the whole been a failure. It has succeeded remarkably well in the sub-tropical pine forests of the Himalayas where an extreme form of the uniform system, reminiscent of the American seed tree system, has been applied with good results ; it has succeeded moderately well in the *deodar* and blue pine forests of Kulu, although natural regeneration has often to be supplemented with sowings as the regeneration period has been rigidly fixed at thirty years for reasons concerned with the rights of the people and unconnected with technical silvicultural considerations ; it has, however, failed in the high-elevation spruce and fir forests of the Himalayas where the presence of a deep undecomposed layer of leaf litter has proved a stubborn

obstacle to the establishment of natural reproduction. In the broad-leaved forests of India it has been found impossible to work to systems of natural seedling regeneration owing to lack of silvicultural command over the reproduction, consisting either in an inability to work to a time schedule as in the case of sal, or in an inability to obtain reproduction in quantity of the desired species and to repress the regeneration of the weed species.

In some divisions of the United Provinces and Bihar, a form of the Uniform System is applied to sal. These forests are in process of conversion from the selection type to the even-aged type. The conversion operations have hitherto been confined to blocks where natural regeneration already existed in the shape of uniformly distributed advance growth, and all that needed to be done was to remove the overwood in one or more stages. It is feared that this system will break down when the conversion operations extend to areas where advance growth is not already present. The same method has been applied to certain teak forests in the Central Provinces, full use being made of existing advance growth, but in that case it is always possible to have resort to artificial regeneration in the event of natural regeneration not being already present or not forthcoming. This remedy is not so readily available with sal, as the species cannot be raised by transplanting or stump-planting and the seeds lose their fertility very rapidly.

By far the greater part of Indian forests which are under any form of systematic management are worked under a system of selective fellings or a conservative and constructive system of improvement fellings or under the Coppice System. Our forests are typically uneven aged and mixed and this fact together with the fact already noted that only a few of the many species actually found are marketable at a profit has made it necessary to regulate exploitation of timber bearing areas by a form of selection in respect of both species and size. This is very different indeed from the European Selection System which is applied successfully to uneven aged forests composed of one or a few species all of which are more or less valuable and which regenerate themselves satisfactorily. In India the natural regeneration of forests worked under the selection method has proved an intractable problem. The cumulative effect of working a forest for the small proportion of valuable species it contains is to favour an increase in the proportion of the valueless species and to reduce the incidence of the valuable ones—a dysgenic tendency which is directly opposed to our interests. Attempts made to overcome this difficulty by artificial regeneration of the gaps left by the selection fellings have been unsuccessful; the regenerated gaps proved not only expensive but were difficult to protect against the competition of weed species and against browsing by wild animals. Success could only be attained when the gaps were made so large in size that they could be dealt with as substantive plantations.

Theory of Compensatory Plantations.—This experience led to the development of the theory of compensatory plantations. It is an accepted canon of forest management that no exploitation fellings may be made in any forest unless there is an assurance of regeneration to replace the trees removed. A literal interpretation of this salutary rule would have meant that our tropical timber bearing mixed forests could not be worked at all as we could not guarantee either natural or artificial regeneration of the desired species to make good the removals—clearly an impossible position. We therefore decided to observe the spirit rather than the letter of the rule, by making plantations of adequate size of the valuable species in carefully selected sites in the forest, leaving the rest of the forest to be stocked by whatever species nature might bring in. We believe that in so far as this procedure will increase the proportion of valuable species in the forest as a whole, it is a measure not merely of conservation but of substantial improvement.

Coppice System.—The Coppice System is applied extensively in the drier types of forests for the supply of firewood and small timber for domestic and agricultural needs. These mixed forests, which often contain a proportion of thorny species, are in general rather open and much subject to grazing. The coppice rotation ranges from twenty to forty years. Experience has shown that even under conditions of strict protection and adequate rainfall, as in the case of the *Eucalyptus globulus* plantations of the Nilgiris, an appreciable percentage of the stools fails to throw up coppice shoots and that this percentage increases with successive fellings. On the Nilgiris the *Eucalyptus*

plantations are rejuvenated by complete replanting after the fourth rotation, replanting being both easy and cheap. But this solution is, however, not feasible for most of the natural fuel forests. In their case it is necessary to supplement the coppice regrowth by artificial regeneration. This is done by either the *taungya* method or by the *rab* method as briefly described in a later paragraph.

Techniques of Artificial Regeneration.—For these various reasons we have paid a great deal of attention to artificial regeneration in India. Our most important species, teak, cannot be satisfactorily regenerated naturally in good quality sites. Further its value is so much greater than that of its natural associates, that, provided silvicultural considerations do not preclude it, it is economically expedient to grow it in pure plantations. Apprehensions as to the dangers of the pure teak plantation have been voiced, particularly as regards the menace of insect damage and the exhausting effect of the teak on the soil factors, but research has shown that these dangers can be prevented and controlled by suitable techniques. Much of our artificial regeneration research has centred round teak, the first successful plantation of which was made over a hundred years ago. We may now fairly claim that the problem of forming and establishing teak plantations successfully and economically in suitable sites has been solved, although much yet remains to be discovered as to the best methods of tending teak plantations. Among the major advances made in India in artificial regeneration techniques may be listed :

(i) the controlled use of fire in regeneration areas,

(ii) the *rab* method,

(iii) the *taungya* method, and

(iv) the use of stumps.

Controlled use of fire in regeneration areas.—European silviculture teaches that fire in the forest in anathema, but it had long been observed in India that the degree of efficiency of the initial burning of the slash in the cleared regeneration site made all the difference between success and failure in planting operations. Provided the fire is not hot enough to bake the soil to a brick-like condition, the better the burn the better is the initial growth of the plantation. Correct burning secures two desirable objects: it destroys the seeds and surface roots of grass and other weeds and ensures freedom from weed growth for a period ranging from one to three years; it stimulates rapid (often phenomenally rapid) growth during the first few years. The reasons for such rapidity of growth are not fully understood, but it is known that the effect is not merely due to the inhibition of weed growth and the addition of the mineral ash resulting from the burn. The burning disturbs the microbiological balance in the soil in a temporarily favourable manner. It is believed that the fire destroys equally the protozoan as well as the bacterial population in the soil, but the numbers of the latter increase initially much more rapidly than those of the former, giving rise to a temporary increase of soil fertility. This, however, fades out gradually in two or three years by which time the protozoan population has increased sufficiently to keep the bacterial numbers in check. Early rapid growth is of obviously great significance in plantation work, especially in dry localities.

The Rab method is an application of the benefits of slash burning to dry fuel forests. The slash left after the extraction of timber and firewood from a coupe is piled in heaps distributed uniformly over the area in patches or in continuous lines according to a prescribed pattern. It is left to dry and is then burnt, the ash being worked into the soil before it is blown or washed away. Seeds are then sown (or stumps planted) in the burnt patches or lines. The resulting plants show remarkably rapid height growth which is maintained for two or three years. In many cases the young plants grow beyond the danger of being trampled or browsed down by the time the coupe is thrown open for grazing—usually at the end of five years after felling. The extent to which this method can be adopted depends on the availability of slash and the funds available for the work, as it is expensive.

The Taungya method consists essentially in the raising of tree crops in conjunction with field crops. As the Burmese name implies, it was first developed in Burma where advantage was taken of the primitive practice of shifting cultivation to form teak plantations in the cleared areas. The method is very simple in outline. A coupe is clear-felled, the timber and firewood extracted and the area turned over to the cultivators at the rate of about

two acres per head. The cultivator then prepares his plot for sowing by burning the slash, uprooting the stumps if necessary and working the soil by hoeing or ploughing. In many cases unfettered cultivation with any approved field crop is allowed in the first season. In the second season the ground is prepared for the sowing or planting of the selected tree crop either in lines spaced in a prescribed manner or in staked patches spaced uniformly. The sowing of the tree seeds and of the field crop is done at the appropriate seasons. The cultivator is usually bound to keep the tree seedlings well weeded and to prevent the field crop from shading and suppressing the seedlings. In protecting his field crop from damage by wild or domestic animals, he equally protects the tree crop. Where irrigation is done in the interests of the field crop the tree seedlings are also benefitted. Cultivation may continue in the same site for one or two years after the introduction of the tree crop, depending on the fertility of the soil and the rate of growth of the tree seedlings.

This system depends on a co-operative effort between the cultivators and the Forest Department to the benefit of both. The cultivator gets a newly cleared site containing the stored fertility of the forest soil. He gets it free of rent or is required to pay a nominal rent. By operating the method systematically the Department shifts the cultivator from site to site, the regeneration areas being disposed conveniently round a central forest village where amenities for water supply, schooling and medical aid are departmentally provided. On the other hand, the Forest Department gets a cheap or free labour force at its disposal—labour is a matter of considerable difficulty in remote forest areas—and secures automatic protection of the plantation. The detailed arrangements vary very considerably from place to place, as may be expected. The method is successful only in those areas where there is a strong demand for cultivable land. Originally employed for the regeneration of teak, it has now been successfully applied to *sal* (*Shorea robusta*), *Acacia catechu*, *Xylia dolabriformis*, *Terminalia tomentosa*, *Pterocarpus macrocarpus*, *Gmelina arborea*, *Alnus nepalensis*, *Bucklandia populnea*, *Cryptomeria japonica*, *Bombax malabaricum*, *Ailanthus excelsa*, *Broussonetia papyrifera*, *Pinus longifolia*, *Morus alba*, *Dalbergia sissoo*, and other species.

Stump planting is a method of restocking clear-felled areas, consisting in planting in crow-bar holes nursery stock of which the tap roots are cut to a length of 9 or 10 inches and pruned of all side roots and the stem cut about an inch or so above the collar. The correct size of nursery stock to be used varies with the species, the usual size being of the thickness of one's little finger. The advantages of stump planting are manifold. When properly stored the stumps (or root and shoot cuttings as they are sometimes called) retain their power of sprouting for at least a fortnight, thus making it possible for them to be transported great distances. The root sprouts first from near the tip and the new rootlets thus tap a lower layer of the soil where it is more moist in dry weather and less subject to variation in moisture content. Advantage is taken of this fact in dry sandy localities by using stumps with roots of considerable length. As there are no transpiring leaves, as in the case of transplants, there is no danger of wilting, and planting can be done in any weather, although in very hot conditions it may be useful to cover the cut stem with earth to prevent excessive drying. The first leaf shoots feed on the stored food in the tap root till the new root system develops. No elaborate soil preparation, such as digging pits, is necessary, all that is required being a crow-bar hole of the right depth in which the stump can be planted. The rate of growth of stump planted stock is greater than that of transplants or seedlings during the first year—a point of great value in regeneration work. The method is, however, not applicable to all species. Teak, rosewood (*Dalbergia latifolia*), sissoo (*Dalbergia sissoo*) and mulberry (*Morus alba*) respond splendidly, but *sal* and, generally, evergreen species as well as conifers cannot be propagated by this method.

Reactions on Silviculture of Modern Trends in Utilization.—The demand for timber in India has hitherto been largely for constructional, furniture or other purposes such as railway sleepers where wood in its native form has been sawn and shaped to serve the purpose in view. Accordingly our silvicultural methods have aimed at producing as quickly as possible large sized timber of the desired species, straight and free from defects. But in recent years there has developed an industrial demand for wood as a result of which formerly valueless

species, such as *Bombax malabaricum*, *Boswellia serrata*, *Adina cordifolia*, find a ready market for special purposes as match splints, packing cases, plywood, etc. Our young paper industry is on the look-out for suitable woods for newsprint, kraft paper and the like. The advances made in laminated construction make it increasingly unimportant to produce large sized timber, while the advances made in wood preservation make it possible to use non-durable timbers for many purposes for which they were once considered unsuitable. Wood is coming to be regarded more and more as a cellulosic raw material to be treated and transformed into processed materials rather than as a constructional or ornamental material to be used in its natural condition. These trends will no doubt react profoundly on our silvicultural techniques.

Need for Afforestation.—There is a general awareness in India that the total extent of our forests is inadequate and that their distribution is unsatisfactory. To correct these, plans for afforestation on a large scale are under consideration in most provinces, notably in Bihar, West Bengal, United Provinces, East Punjab and Madras. As in many cases the areas to be afforested will be waste lands considered unsuitable for the extension of cultivation for one good reason or another, the work of afforesting them will present numerous difficulties which it will be the task of forest research to solve. Another serious problem which is engaging our attention is the use of silvicultural techniques in the rehabilitation of denuded and eroded lands and generally in soil conservation. But this is a large and complicated subject which cannot be dealt with in this paper.

Silvicultural Research.—Research in the productive, protective and utilization aspects of forestry is centralized at the Forest Research Institute, Dehra Dun, which also trains forest officers and forest rangers, for all-India. The silvicultural techniques adopted in the country are the results of research carried out at the Forest Research Institute and in the Silviculture research divisions in the Provinces and States. The research programmes both at the Central Institute and in the Provinces are based on the resolutions of periodic Silvicultural Conferences held at Dehra Dun which are attended by delegates from all Provinces and the major States. The last Conference was held in 1946.

Application of Statistical Methods.—The publication of an Experimental Manual for India by Champion in 1931 in pursuance of a recommendation of the Silvicultural Conference of 1929 marked the starting point in standardizing methods of experimental research in Indian forestry. The importance of statistical analysis was recognized by the inclusion of a chapter on statistical methods in the Manual. The Fourth Silvicultural Conference held at Dehra Dun in 1934 discussed methods of statistical analysis of data collected in the course of silvicultural experiments. Between 1924 and 1939 considerable progress was made in the Forest Research Institute in the study of statistical methods of design and analysis of experiments. Two Statistical Assistant Silviculturists were sent in 1936 and 1937 to the Indian Statistical Institute, Calcutta, for special training under Prof. P. C. Mahalanobis, F.R.S. As a result a clear exposition of the principles and methods involved was presented to the Fifth Silvicultural Conference in 1939, which resolved that the chapter on Statistical Methods in the Experimental Manual should be re-written so as to include the latest advances made in statistical analysis and experimental design.

The Sixth Silvicultural Conference held in 1945 resolved that in view of the great developments that had taken place in statistical science since Champion wrote the chapter on statistical methods in 1931, a separate Statistical Manual dealing with principles of design and analysis of forest experiments should be produced. Accordingly Griffith and Sant Ram published in 1947 the "Statistical Manual" as Vol. 2 of the revised Silviculture Research Code.

A further step forward in this direction was taken in 1947 through the creation of a Statistical Branch in the Forest Research Institute, Dehra Dun, with a highly qualified and experienced Statistician (in the person of Dr. K. R. Nair) at its head. A short refresher course for provincial Silviculturists in statistical principles of design and analysis of experiments was conducted in 1948 and it is hoped to make this a regular annual feature.

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THE APPLICATION OF GENETICS TO FORESTRY

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SUMMARY

The possibility of forest tree improvement through genetical methods is beyond any contradiction. The use of breeding techniques in tree improvement is of recent origin, though provenance studies on the adaptability of races to particular localities date back to the end of the last century.

More precise methods in selection have been taken up and adequate testing methods evolved.

Hybridization and the employment of heterosis have already yielded valuable results and the difficulty of time involved therein has been overcome by the induction of early flowering and fruiting, through such techniques as strangulation, grafting, root pruning, etc. The production of hybrid seeds on a commercial scale can be brought into the scope of economic possibility through cleverly designed Tree Seed Plantations.

The rapid progress achieved in the improvement of agricultural crops through cytological research and the use of polyploidy has had its effect on forest geneticists who have furnished evidences of the use and value of such techniques when applied to forest tree improvement.

Introduction.—The vast potentialities unearthed by the science of plant breeding, genetics and cytology (Cyto-genetics), in the improvement of plant species, have been hitherto overlooked by the forester. This negligence has been not because the forester, with some knowledge of the fundamental sciences, assumed for a moment that the laws of heredity operate in one way in the case of agricultural and horticultural crops and quite another in the case of forest trees. The rapid progress made by these, instead of encouraging him in this direction, seems to have overawed him, mainly because of certain over-emphasized advantages which they possess. It is true that whereas the agriculturist and the horticulturist have to experiment with bi-annual, annual, or short term crops, the forester has to reckon with hundred or hundred and fifty year generations and could not be induced to take interest in Forest Genetics, which seemed meaningless in such brief mortality. This view is no longer tenable in the light of recent researches. Nor is a comparison between the breeding of forest trees and herbaceous plants always correct or helpful. We should not gaze at the more favoured position of other plant improvers but rather turn the matter the other way round. "Let us not contemplate their swiftly changing generations, but rather the short life of their plants compared to that of our forest trees. Paradoxically, one might say that, as regards short-lived plants, one must attract types of seed-consistency in order to preserve them, whereas in forest trees one can preserve valuable hereditary tendencies in the same individuals, may be for centuries". Moreover, "The slower the procedure, the sooner a start must be made, as the improvement of species is a matter which cannot be neglected if forestry is to meet the constantly rising demand for production. Also, it is a fact that only when one really seriously tackles a question, one finds the right way, i.e., the shortest and best one".

Some work in the past half century has been done in Europe on the geographic location, comparison of the normal with chance mutants, etc. In Switzerland, Englor, Nageli and Burger started studies towards the end of the last century on site races, form races, the influence of geographical location, latitude, altitude, soil, precipitation, etc. The Botanisches Institut der Forstlichen Hochschule Eberswalde, initiated studies on climatic races of *Pinus sylvestris* and *Pseudotsuga taxifolia.* It was not, however, till as late as 1925, that the first real forest tree breeding institute was started in Placerville, California, as the Eddy Tree Breeding Station and later called the Institute of Forest Genetics. In 1932 was

inaugurated the Forest Tree Breeding Union of Germany. In Sweden, Nilsson-Ehle discovered the famous triploid aspen in 1935, which acted as a stimulus and resulted in the corporate existence of the Swedish Society for Forest Tree Breeding in 1936, and also the initiation of the Tree Breeding Institute at Ekebo near Svalof.

It is most disappointing, however, that no serious thought is being given to this subject either in England or the Commonwealth. Isolated attempts were made in India by Champion on *Pinus longifolia* and Laurie (1936) on teak. The Dominion of Canada has taken up tree breeding as one of the research subjects since 1938 and the more recent attempt is made by the Union of South Africa (1943), with the appointment of a geneticist for the wattle industry. The present article is being written in the hope that Forest Tree Genetics may attain a rightful place in Indian Forestry. It may also serve to remove certain misconceptions, as to the practicability of this subject, from the minds of foresters in general.

The need for going into the genetical aspect of forestry is urgent, especially when almost every Province is embarking on large afforestation schemes and the forester has to see that he brings up the most superior genotype. A good percentage of our forests, moreover, are maintained under the Selection System which results in the gradual removal of the better types and steady racial impoverishment. As pointed out by Austin (1937), uncontrolled exploitation and "the North American system of selective fellings are dysgenic and breeding methods are necessary to improve not only the quality of trees, but to maintain them at their present quality level". Another very strong reason to take interest in this subject is the fact that India, unlike the European continent and most of the other parts of the world, has areas of comparatively undisturbed forests. The forests of the Andaman Islands, in particular, are one of the few forests in the world which are comparatively but little worked by civilized man. Whatever natural forests we have are of immense value to the geneticist, as these offer a gene complex which has arisen after centuries of natural selection and are the nearest approach to a dynamic equilibrium constituting the biome. This has resulted in the so called locally adapted races. The destruction of these may result in a loss that ages of silviculture and forestry may never replace. At the same time, these virgin forests may give very valuable genetical and ecological clues to follow and improve upon what nature already has.

Provenance Studies.—Before embarking on a detailed programme of genetical investigation, it is of utmost importance to survey and find out the full extent of natural variability of a species* over its entire range of distribution. The importance of this can only be appreciated when one bears in mind the fact that most, if not all, species consist of races or strains which have developed under specific environments. If one examines the entire pattern of genetical variation of these races or strains, it will be found that at times there is a definite gradation of their characters or groups of characters, either physiological or morphological or both, in relation to geographical distribution. For this the term cline† has been used, topoclines (used by Huxley), geoclines (used by Gregor), ecoclines, etc., being distinguished according to the magnitude and type of variation. An interesting example of this has been mentioned by Lindquist for Eych Elm with a North to South gradient in leaf form, being narrow in the northern parts and broad in the southern. Useful practical conclusions can be drawn by the geneticist from such data. Thus, it may be possible to associate leaf form with greater resistance to frost or fungal attack. Another interesting example is that pointed out by Meville (1940) in the case of the three major varieties of *Pinus nigra* Ann., which form a topocline in respect of needle length.

Having accepted the fact that types constituting a widely distributed species show differences in their morphological, physiological or biochemical characters, as a more or less direct causation of natural selection, under different environments, and also bearing in mind that these characters are genetically heritable (leaving aside the superficial or

* Our present remarks are confined to genetical investigations within a natural biotype group. It is beyond the scope of the present article to dwell upon the taxonomic aspect of the criteria necessary for the discrimination of a species. For purposes of a geneticist, it would suffice to affirm that interracial, intervarietal or interspecific variations differ only in degrees.

† Space does not permit to enter into the theoretical interpretation of these facts and a discussion of the clinal concept. Non-clinal distributions, however, should also be kept in mind.

phenotypic variations), the problem of the geneticist is that of finding out the climate or physiographic race that will grow best in any particular region or locality. This investigation, which is generally termed "Provenance studies", will give him the material on which to start detailed genetical experiments. The detailed meaning of Provenance and its study has already been stressed by the author in a previous article and it would suffice here to cite a few examples to further illustrate its practical importance.

In the case of *Pinus sylvestris*, Hess (1942) in Switzerland found that two races could be distinguished on the differentiation of bark characters—the grey barked and the red. The former was found to occupy chiefly the dry slopes of the Rhone Valley up to a thousand metre elevation and is characterized by poor diameter and height growth. The red race had wider distribution between elevations of a thousand to two thousand metres. In the former case the trees rarely exceeded 15 metres in height and 30 c.m. diameter at B.H., had a strong branchiness and a flat crown, and the growing stock never exceeded a hundred cubic metres per hectare. In the latter case the trees reached a height of twenty-five metres and had a diameter of 60 c.m. at B.H. with a clear bole and a pointed crown ; the growing stock exceeded three hundred cubic metres per hectare ; and the quality of timber was very superior to the former. The reports of Delevoy (1937), Dengler (1938), Littlefield (1939), etc., also show the great importance of racial differences with regard to the timber yielding capacities of the various other races of *P. sylvestris*.

The resistance of Scots pine to *Peridermium pini* and *Cronartium asclepiadeum* is believed to depend on genetical constitution and Liese (1936) recommends selection against these diseases. Racial and individual plant resistance to *Brunchostia destruens* has also been investigated by Wettestein (1933).

In connection with provenance studies on *Picea abies* (Spruce), the work of Rubner (1936, 1939, 1941, 1944) and his discovery of altitudinal races is of great interest. His conclusion is that height growth of plants from seed from higher elevations was relatively less than of plants from seeds from other provenances in the same forest area. According to him it appears that the elevation line dividing the fast and slow growing races varies for the different mountain regions, being relatively higher in the more southern mountains of Germany.

The fact that timber yield differs with races in *P. abies* has been proved by Rubner (1936) and Fabricius (1938).

Pseudotsuga taxifolia (*Douglas Fir*), has a wide distribution extending from sea-level to altitudes of 5,000 feet or so and is an important timber of the Washington and Oregon zone. The difference in growth rate between the Pacific Coast and the Rocky Mountains forms was recognized in early Europe where this species was introduced over a hundred years ago. European experience shows that the Pacific form usually grows more rapidly, but it is much less hardy than the other when subjected to low temperatures. Seed planted in Russia by Count von Berg also showed that the Pacific form was much faster in growth. Provenance studies in Germany carried out by Liese (1939) have revealed valuable and interesting results. Briefly, his results show that the Pacific coast form is attacked by *Chermes coolevi*, but not the mountain form ; root rot attacks both and the former is more resistant to *Agaricus* and *Rhabdocline* attack.

On the European Larch (*Larix europea*), provenance studies have been extensively carried out in Germany and the observations of Münch (1933) show that diseased stands of Larch were found invariably to be of Tirolese origin, whereas the Sudeten race of Larch appeared to be immune, for all practical purposes, over the whole of Germany. This high degree of immunity is ascribed firstly, to the similarity of climate between its natural habitat and the rest of Germany, which enables it to fit better in the seasonal cycle of growth ; and secondly to its relative frost hardiness.

The report of Rubner (1941) on ten-year sample plot trials with Larches of different seed origin, including various regions of the Alps, Eastern Sudeten country, Higher and Lower Tatra, Poland and Scotland, is of great importance. The fastest and earliest growth was exhibited by the Sudeten race, which in

the lower Erzgeberge reached a height of about 5·75 meters. The Wienerwald, Higher Tatra and Poland provenances were slightly slower growing. The Alpine forms from the Cavalese (800–900 m. altitude) and Bluhnbach (800–900 m.) though of slower growth, could still be regarded as fast growing ; those from higher altitudes showed medium growth, while those from very high altitudes (above 1,800 m.) of central Alps, were distinctly slow growing.

European Larch provenance studies have been of interest, though recently, in Great Britain a number of experimental plots were laid in North and South Wales, the earliest of these being at Radnor in Radnorshire. Among the various races examined (Varma 1947) the Scotch race of European Larch showed marked superiority not only in regard to height growth, but also in stem-form and the minimum of damage to the current shoot. The Austrian race was the worst, while the Bohemian came out as a close second to the Scotch.

An attempt was made by Varma (1947) towards the physiological determination of relative hardiness of two races of European Larch, on the criterion that the more hardy one will have a greater osmotic concentration of the cell sap than the others. For the same reason, tissues of the former would show less lethal effects at a greater concentration of the extra-cellular solution than the latter. The Lotschental race of European Larch proved to be more cold resistant than that from Murau. The results of Day with experiments on the induction of injury by freezing, are in agreement with the above findings.

Tectona grandis (*Teak*).—Provenance studies have been carried out in Java and according to Coster and Eidmann (1936) and Coster and Hardjowasono (1935) the Javanese types tended to be the tallest and stoutest in comparison to varieties from India, Burma, Siam and Indo-China. The investigations of Beard (1943) prove the marked superiority of teak races of Burma as compared to those in India, under the climatic conditions of Trinidad. Teak co-operative experiments are in progress in India (Laurie 1939), with a view to test the germination, rate of growth at early youth, volume production per acre, timber form, suitability for growth in localities outside their local range, etc. According to the preliminary results obtained (Sen Gupta 1939) seeds of local origin show superiority to those of other regions.

According to Coster and Eidmann (1934), teak races differ *inter se* in fruit and seed size, and in germination capacity. Laurie and Griffith (1941) presume that the anatomical characters of the wood are probably controlled by genetical factors. They also think that leaf texture is probably connected with insect resistance, the former being determined by the genotype.

Breeding Methods.—Having collected as abundant material as possible of the comparatively superior forms, in which the importance of the genotype in relation to any particular environment in the production of favourable characters is fully proved, the geneticist is in a position to employ selective or combinative breeding, heterosis, or polyploidy for raising new and superior genotypes. We shall endeavour to elucidate each of these techniques in the above sequence and deal at some length with the obvious practical difficulties which have hitherto deterred the forester from pursuing these.

Selection.—Selection as the term implies, is merely the sifting of the types which the breeder thinks are of greater value to him, from a mass of varying individuals. A more or less similar procedure is adopted as in the case of crop plants. The simplest and perhaps the earliest form of selection practiced is what is known as mass selection, where seeds are collected from trees with an apparently superior look. From the progenies of these a similar selection is made and this process is continued, for generations. There being no control on pollination at all, the population is genetically highly heterozygous and one cannot be sure of the fact that a superior looking tree will invariably give an equally good offspring. Here it may be objected, as was done by Frankhauser and Lubjako (1941) that characters such as vegetative vigour and wood quality cannot be directly estimated from the seedling and one may have to wait for a considerable length of time before one can judge the results of any selection. The time involved in a breeding programme can be greatly reduced if a search is made for juvenile characters and these be correlated with valuable adult characters. Again, it may be rightly asserted that skilful

thinning by the forester with a good knowledge of silviculture and ecology is a method of selection which he has practiced since long. As emphasized by Richens (1945) "It is unfortunate that breeding and silviculture have come to be regarded in some quarters as rival techniques rather than complimentary, which is their true relationship. In addition it may be pointed out that selection during thinning is only eliminative and negative, excluding inferior individuals but not developing superior genotypes ; there is also the danger that rare but valuable types may be exterminated. Moreover, low thinning does not select the sum total of desirable characters but places undue emphasis on competitive vigour, which is only one of the many features which a breeder has to bear in mind. The objection that breeding disregards local adaptibility applies only to bad breeding, since it is generally recognized that new varieties must be thoroughly tested in the region into which they are to be introduced".

Another method of selection is that known as "Mother Tree Selection" where trees of superior quality are used as mother trees so that the female parentage is known. But as there is open pollination, there is no control over the male parent. The same process is repeated in the next generation.

Perhaps a more scientific method of selection is that known as "Individual Tree Selection" where single plants of outstanding quality are chosen. From these either pure seeds are raised by the use of self-pollination, or pollen from another plant of proved genetical superiority is taken and artificial pollination resorted to. In this form of selection, both the male and female parentage is known and fairly accurate forecasts can generally be made as to the final results, depending on the Mendelian laws of inheritance*. The first such instance where artificial pollination was resorted to, in order to prove heredity in tree species, is that of Sylven [Svensk Skog Tidst (1910)] on Scots Pine and Norway Spruce.

The use of natural selection in trying to bring about acclimatization of a race, is another form of selection. In this connection, the work of Arzybasev (1939) is of interest. Trees from the Pacific Coast of North America were planted in different localities in successive generations. The first generation was planted in Alaska, the second in Finland and the third in Moscow and thus a progressive adaptation was aimed at ; the ill-adapted genotypes being eliminated and only the hardier types remaining.

Testing Methods.—On account of the long life, large size and a large root system, it is conjectured that as a greater interplay of environmental factors is likely to influence the development of forest trees and leave a marked effect on their phenotypic expression. As such, selection of trees based on their phenotypic expression in an extremely risky procedure. For this reason, it has been asserted by foresters, not without justification, that progeny testing is the only means of proving the superiority of the genotype. That progeny testing would involve considerable time has been one of the main stumbling blocks in the way of the forester. It is essential to resort to a quicker method than progeny testing or more reliable than selection on the mere examination of the phenotype. In this connection reference could be made to an extremely stimulating article by Syrach Larsen (1947) entitled "The estimation of the genotype in forest trees". His recent experiments in this line are of profound interest. He had adopted vegetative propagation in the estimation of individual trees' genotypes and though the experiments are very recent and on a small scale, they distinctly reflect the genotype of the "mother tree". To use his own words "by vegetative propagation from each of a number of selected trees, a group of individuals has been produced which were treated uniformly and planted out under the most uniform conditions, thereby securing, as far as possible, uniform external influence on the different genotypes. The work is now carried further by testing also the indivitual genotype under varying external influences. This latter part of the work demands the greatest number of uniform, vegetatively propagated plants and is as yet only in its beginning".

"When, as foresters, we desire to find the most valuable genotypes, the individuals combining a desired shape with a strong growth-rate

* We are assuming, for the sake of avoiding complications, that the laws of heredity as followed and recognized by classical geneticists hold good. There is no doubt that some of these have been modified in the light of recent researches. Not only this, but the entire conception of heredity and the Mendelian laws have been thrown overboard by the new Physiological genetics, evolved by the Russian geneticists championed by Lysenko. It will be out of place to enter into this controversy.

rank first and foremost. But the testing by vegetative propagation may, however, easily be carried on as regards observations on resistance to various diseases, flowering conditions, leafing, shoot ripening and other factors of importance to improve growth of trees".

"As vegetative propagation of the majority of forest trees is most easily done by grafting, our work has been carried out chiefly by this method, though I realize that cuttings—where the plants are on their own roots—would be more advantageous ; this, however, must be aimed at in future experiments. As the grafting of selected trees, however, show such remarkable uniformity within each individual 'clone', this seems to prove that the stock in these cases has been of less importance. In other words, the different clones show such mutually great divergences that even a comparatively rough testing method such as the grafting on a population of stocks with all their varying qualities, will show the characteristic genotype of the clone from which the graftings were taken."

"In future experiments with cuttings, graftings or buddings on more uniform stocks, it may be possible to detect even finer grades. Should it prove impracticable or too difficult to work with cuttings, an alternative may possibly be found in the use of more uniform stocks for grafting, similarly to what is now used with several fruit trees. In this way, uniform plantations could be obtained in which root and top would be of mutual uniformity."

"Through observations in the forest, we may get an idea of the variations within a certain tree species, but as the variants are only single trees of varying shape and appearance, we can only surmise what is due to heredity and to environment. It is quite another matter, though, if we have produced by vegetative propagation, from each of the noted trees, a number of individuals, and these have been planted out in such a way that the clones may be compared row by row. In our experiments it strikes me forcibly how surprisingly fine divergences we may notice between the individuals within the same species and plantation, when the trees are grown in rows for comparison".

"It seems to me of importance", concludes Dr. Larsen, "as soon as possible to include the method of vegetative propagation in the estimation of the genotype, i.e., the qualities contingent upon hereditary tendencies".

His experiments include Beech, Ash, Larch, Norway Spruce and Douglas Fir. When once the good genotypes have been determined, the aim of the forester should be to preserve these by the help of vegetative propagation, which fact is most valuable from the breeder's point of view.

Hybridization.—Having collected as large an assemblage of promising genotypes as possible, the breeder is in a position to combine the good qualities of different individuals and evolve a variety which may be of great economic value. Intervarietal crosses are very successful and yield fertile hybrids. There are many examples to that effect. Interspecific crosses have also yielded some very valuable results but are more difficult to achieve and may produce sterile hybrids in some cases. Johnson (1939) Smith and Nicholas, etc., have listed the interspecific hybrids, many of them of great economic value.

It is a well established fact that by crossing closely related species, hybrids, are produced, which in the F_1 generation show prolific vegetative development and are said to manifest "Hybrid vigour" or "Heterosis". This phenomenon can be of considerable use in forestry, due to the long life of trees. Seeds from the hybrid may not be as valuable as the hybrid itself, as hybrid vigour has been proved to be at its highest in the F_1 generation in most agricultural crops as well. This is also supported on theoretical grounds, as segregation of characters is bound to take place in subsequent generations. The most outstanding example of hybrid vigour is that observed in the case of the Japanese–European Larch crosses (*Larix decidua Mill.* × *Larix Kaempferi Sarg*). In this case, strong growth is combined with a fine appearance and increased resistance to *Dasyscypha willkommi*, causing cankers on Larch*.

Interspecific crosses in the Poplars is an interesting study in forest tree breeding. Being dioecious and anemophilous and being propagated very easily as cuttings, several of its varieties have long been cultivated. A considerable amount of work has lately been done in the Scandinavian countries on these and the

* With reference to hybridization in relation to plant diseases, Dr. B. K. Bakshi, Asstt. Mycologist, Botany Branch, Forest Research Institute, Dehra Dun, points out that hybrid vigour need not go hand in hand with resistance to disease. Planted forests of selected strains may become comparable to orchards in which susceptibility to fungal diseases is apparent.

Aspens. A large number of interspecific crosses have been reported, showing a marked degree of heterosis—there being an increase in growth rate in the following :—*Populus alba,* × *P. grandidentata ; P. alba,* × *P. nigra ; P. alba,* × *P. tremula ; P. alba,* × *P. tremuloides ; P. deltoides,* × *P. nigra ; P. laurifolia,* × *P. niqra ;* and *P. alba,* × *P. tremuloides*. Resistance to disease or pests as a direct consequence of hybrid vigour is reported by Wettstein (1937).

The production of hybrid seeds on a commercial scale is not an insurmountable proposition. As a remarkable illustration, the seed farm of Japanese–European Larch hybrid established by Dr. Syrach Larsen in Denmark may be mentioned. A study of their flowering habit was made and the ones showing metandry (flowering of the female flowers before the male ones), was chosen as mother trees. From these, grafts on seed trees were made in rows, which amounted to the manifestation of the one and the same individual on a large number of separate roots. Alternating to these rows were made similar grafts of the desired father species such that, while the former produced female flowers, the latter furnished the pollen from its male flowers. Such a plantation, once established in a locality, well isolated from any other stand of the species involved, may well produce the necessary hybrid seeds year after year. Another interesting example mentioned by Dr. Larsen is that of *Pinus sylvestris* in Norway and Sweden. This species shows great variation in the time of flowering in different localities due, partly to the place of growth and partly to "Hereditary deviations". If some of these trees are moved from the high northern localities to the more southern, or vice versa, different flowering dates may be shown by them in comparison to the native ones. These may well serve the purpose of cross-pollination.

An objection frequently urged against the initiation of a tree breeding programme is that forest trees take a long time to come into flowering. Methods of stimulating flowering and fruiting have been evolved which give very promising results in a reasonable length of time. The more important ones are :

Strangulation.—This is a method frequently employed in horticultural practice and consists of winding a thin iron wire a few turns round the trunk of a tree. As the stem increases in girth, the wire tightens up and the downward flow of sap is partially checked. Care should be taken not to tighten the band very hard initially, nor should the strangulation be continued so long that the downward flow of sap is completely stopped and the root system degenerates. This partial check in the normal assimilative processes of the tree seems to stimulate abundant flowering. At times a tree may not react so favourably and in such cases, a second strangulation, just above the previous one, is seen to bring forth the desired result. Another fact worthy of notice is that a stimulus in flowering, once induced, seems to continue for a number of years after the band is removed, though the general vegetative growth of the tree drops.

This method has been used in quite a number of forest trees by Professor Sylven at the Ekelo Institute, since 1938. It was also tried by Hogler Jansen in Halsingborg, Sweden, with positive results in Alder, Birch, Oak and Maple in hard-woods, and Pine, Sitka Spruce and Larch among the conifers. Strangulation of young trees of Alder, Birch and Maple by Lindquist (1948) showed profuse flowering after one year. He mentions an Oak tree about 3 metres high strangulated in 1938 yielding more than 1,500 acorns thereafter, and fruiting nearly every year. The same tree yielded in the autumn of 1945, about 1,000 acorns after 5 years of strangulation. The suggestion has been put forward that strangulation induces the formation of flower-inducing hormones which, once initiated, goes on for several years.

Grafting.—It has long been noticed by horticulturists, as well as botanists working on forest tree species, that grafting often gives a richer and quicker seed production. Remarkable pioneering work has been done in this connection by Dr. Syrach Larsen in Denmark, which gives quite conclusive evidence of the above fact. The technique of grafting is similar to that used in horticultural practice, i.e., the use of a stock and a scion, or bud grafts. A few of his experiments may be quoted. Among his grafts are 68 Larches grafted in 1937. These produced 3,805 cones in 1942, from which he counted on getting 28,550 plants. A 9-year Ash graft in the Spring of 1934 yielded, 1,579 seeds which, per hectare of 500 trees, would give nearly 800,000 seeds.

Interesting results have also been reported from the work of Hogler Jansen in Sweden.

He used stocks which belonged to a different species than the scions. Thus there was marked flowering by grafting Aspen on a stock of *Populus trichocarpa* within two years, whilst the same Aspen, when grafted on another stock of Aspen, failed to produce any flowering. Taking a clue from this, he has attempted grafting of Pine of different Swedish provenances. Flowering has already started on some of these and his final results are awaited.

It is also asserted, not without evidence (Lindquist 1948), that grafts of forest trees on small and abnormally rich flowering stocks, will produce a similar profusion of flowering on the grafted tree. Such dwarfed, much branchy and abundantly flowering trees are frequently met with by the forester and are generally cut out as being undesirable in thinnings. It is of great genetical importance to the breeder to preserve such types for the production of slow growing stocks, which have an abundance of early flowering.

Root-Pruning.—Another technique for the induction of early flowering is that of root-pruning. This technique has been tried with success on European Larch plants at the Genetical Institute, Ekebo, Sweden.

Cytological Research and Polyploidy.—Cytological research on forest trees was, till recently, looked upon as being purely of academic interest. Recent investigations into the genetical aspect of trees have yielded results of great economic importance. Furthermore, these have helped in the interpretation of some of the most intricate problems and given very valuable indications on the lines on which the breeder is to pursue his experiments.

It is common knowledge to the breeder, that quite a few of his interspecific hybrids may prove to be sterile and it is here that he can get valuable help from cytology. A cytological study will generally reveal the fundamental cause for sterility, as example, one may detect the irregular formation and segregation of bivalents in meiosis, failure of pairing of a few chromosome sets, or such aberrations in them as inversion of translocation. Again, if one observes that the chromosome complements of two species are the same and on crossing the pairing is regular, one may safely say that these two species are closely related and will give fertile hybrids.

Artificial induction of polyploidy has opened a new vista for plant improvement and very striking results have already been achieved in agricultural crops. The chomosomes, or the bearers of hereditary characters (leaving aside the question of cytoplasmic inheritance, for the sake of simplicity) appear in a characteristic number in every species and are double in number in vegetative cells, as in the generative cells. The number of chromosomes in the former is called "Diploid" number and the latter "Haploid". It may occasionally be observed in nature, or as a result of scientific treatment, that individuals with three sets (Triploids), four sets (Tetraploids), six sets (Hexaploids), eight sets (Octoploids), or a multiple of the basic set of chromosomes in the vegetative cells, may arise. With the increase in the number of chromosomes, there are vast changes not only in the quantitative characters of a plant, either positive or negative, but also in adaptability and resistance to disease. It is the aim of the breeder to evolve chromosomal races of tree species showing the maximum vegetative vigour and adaptability. It is generally seen that plants with a higher set of chromosomes than three or four are abnormally poor. Experimental evidence also goes to show that triploids and quadruploids are generally highly fertile and may be used in overcoming sterility in the normal hybrids. The reason for this lies in the fact that, with the duplication of the chromosome set, the pairing efficiency of the chromosomes is increased, especially in the F_1 hybrids, where homologous chromosomes may be few.

As an illustration of the economic results achieved through the utilization of polyploidy, the example of the "Giant Aspen" in Sweden may be quoted. This tree attracted the attention of Nilsson-Ehle as having exceptionally large leaves, much faster rate of growth, a much larger size than the normal Aspens, and an exceedingly fine appearance. On detailed examination it was found that it had a chromosome number equal to 57, i.e., three times the normal haploid number which is 19. This led to a vigorous investigation into the problem of tree improvement through cytological and genetical research. This first triploid to be discovered was responsible for the founding of

the Tree Breeding Institute at Ekebo, where remarkable results have already been achieved under the direction of Sylven. A further series of crosses were made and quite a few tetraploids, having high economic value, have been the result.

As to the reason for the emergence of plants with an increased number of chromosomes, the position is not yet clear. Several types of treatments are seen to bring about such a change—shocks of temperature, wounding, repeated decapitation and callous formation and the application of chemicals. The last method has proved to be most fruitful and the bulk of literature accumulated on experiments with herbaceous plants in America by people like Blakesee, Belling, etc., is a subject by itself. The former was responsible for utilizing colchicine for this purpose and, since then, it has become the "wonder chemical" of the breeder. Other chemicals like acenaphthene, heteroauxin, etc., have also been used with varying success. Colchicine has also been used on forest trees and there are bright indications of its success, even with conifers—a feature which was considered to be impracticable till quite late. The author had the privilege of investigating some European Larch polyploids in conjunction with Keillander at Ekebo and some interesting results are expected.

Conclusion.—An attempt has been made to deal with genetics in forestry in the hope that some of the basic principles may be conveyed to foresters in general, in view of the fact that much can be done on individual initiative, which may act as a valuable guide to the breeder. A few of the outstanding problems and difficulties in the initiation of this subject as a practical science have been discussed. There is no denying the fact that there are obvious practical difficulties in making a start, as there are in any other subject. With this in mind, adequate illustrations have been given which may lend thought on the type of observations needed, especially in provenance studies which are the starting point in genetical research. Such difficulties should not detract the forester from availing of the immense potentialities that this subject holds, especially when there are conclusive and concrete evidences to that effect. The Scandinavian countries and the U.S.A. have already given the lead and it is encouraging to see the keen interest that the forester has started taking in genetical problems in those countries. Forest tree breeding has become "like soil science, entomology and general botany, an auxiliary science to silviculture and should not be omitted from modern forestry".

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SEASONING PRACTICES AND MANUFACTURING OPERATIONS FOLLOWED BY VARIOUS WOOD WORKING INDUSTRIES OF U.S.A., CANADA AND ENGLAND

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PART II

(*continued from January 1950 issue*)

SUMMARY

The article describes the method of seasoning wood generally followed by tool handle and aircraft propeller makers of U.S.A., and by the furniture manufacturers of England. Some important aspects of the manufacturing techniques are also discussed.

Indroduction.—In part I of this article, the methods of handling sawn material in the timber yards and manufacturing concerns of U.S.A., Canada and England were described. The details of the method of seasoning wood for shuttles and bobbins were also given, along with a brief description of the manufacturing operation of the same. Part II of the article deals with the method of seasoning wood and the method of manufacture of various kinds of handles, aircraft propeller blades and furniture (on mass scale).

(a) Tool handles, handles of agricultural implements, small handles, golf club shafts and golf club heads

General.—Ash and hickory are used for various kinds of handles. Hickory is used for golf club shafts and Persimmon is used for golf club heads. The timber is usually received in the form of logs which are cross cut into smaller bolts. The latter are sawn with bark on into 1″ to 2″ thick planks which are then sawn into scantlings, varying from 1″×1″ to 2″×2″ in cross section for the manufacture of handles. A certain amount of timber comes to the factories in the form of flitches also. These are also sawn into scantlings of required cross section. The half-wroughts of golf club heads of Persimmon are obtained by marking out the surface of sawn timber by means of a template and cutting the wood along the lines on a band saw. The half-wroughts so obtained are about 6″ long and 2″ thick with a tapering surface. The ends of these blocks are immediately dipped in molten paraffin wax to prevent end-splitting during subsequent seasoning.

The practice of seasoning followed in different factories is not the same. It is surprising to learn that some factories thoroughly season the timber in the form of scantlings and then make the handles, others make the handles from thoroughly green wood, then dry the semi-finished product. Both are satisfied with the results. Some of the common practices of seasoning and manufacture followed in the American factories are described below.

(i) *Tool handles, and handles for agricultural implements*

Seasoning and manufacture.—Green scantlings of timber (ash), about 2″×2″ in section, are fed in the rounding machine from which they come out as round poles, which are then cross cut into exact handle sizes for agricultural implements. The defective pieces are cross cut into smaller lengths avoiding the defects. The sound pieces so obtained are used as common types of tool handles.

The semi-finished round poles obtained as above, are then seasoned stacking them with the help of crossers on trolleys, which are pushed into drying kilns. It takes about a week to dry the wood at 120° F., 72% relative humidity. No degrade in the wood during kiln seasoning from green condition was noticed. The seasoned handles are then shaped at the ends to take metal fittings, sand-papered, waxed, individually inspected, graded, marked and then packed. During the course of inspection the long handles used for agricultural implements are bent through a certain angle with a lever in the middle. Those with cross grain break, and they are thrown away.

(ii) *Golf club shafts and small handles*

Seasoning and manufacture.—The timber (hickory) for golf club shafts and small handles is first air seasoned in the form of blanks about $1'' \times 1''$ in cross section. These half-wroughts are stacked in the open crib manner in air seasoning sheds. The drying operation is then completed in seasoning kilns. Sometimes only air seasoned stock is manufactured into handles without resorting to kiln seasoning.

The small handles and the golf club shafts are made by feeding the seasoned blanks into rounding machines. The shafts of children's golf clubs are made by feeding narrow planks, say 3″ to 4″ in width, into a combined cutting and rounding machine. The blanks so fed come out as a number of round rods at the other end.

For the purpose of finishing, the handles are first sand-papered by putting them in a drum whose interior surface is lined with sand paper, and in which small rolls of sand-paper are pasted on to several wooden rods fixed in the drum. The drum is rotated and the handles get sand-papered by rubbing action. Similarly the waxing of handles is done by keeping them in a drum along with a few lumps of beeswax and rotating fast the drum, for a few minutes.

(iii) *Golf club heads*

Seasoning and manufacture.—The blanks for golf clubs heads are small blocks of wood, 6″ long, 2″ thick. These are made of Persimmon. For the purpose of air seasoning, the blanks are piled in big heaps on raised wooden floor provided with openings for admitting fresh air. The heaps are covered over with the hessian cloth for slowing down the rate of drying. The blanks are turned over every four or five days to get uniform drying in all the pieces. After about a fortnight, the hessian cloth is removed and the drying of blanks is continued in open heaps for another two months. The air dried blocks are then open piled without crossers in seasoning kilns where the drying operation is completed

The seasoned blocks are then manufactured into golf club heads on a copying lathe. The lathe carries a metal golf club head as a 'form' and it takes five blanks at a time for the cutting and turning operations. After manufacture, the heads are sand-papered and polished.

(b) Mass production of furniture

General.—Due to the war time restriction imposed on the design of furniture and the use of timber, only utility furniture including chairs, tables for general use and dining-room tables, side-boards, wardrobe almirahs, beds, ships' furniture of bent as well as of ordinary wood and simillar items were produced in England up to December 1948. The manufacture of a certain quantity of upholstered goods was also permitted. Oak, ash, birch, beech, a little Burma teak, with face veneers of walnut, mahogany and oak for laminated boards for gramophone, radio and television cabinets, were found to be commonly used for furniture making by the British manufacturers.

Seasoning.—Most of the timber comes to the furniture makers in the form of sawn planks and scantlings. Some of the furniture factories have small sawmills in their own premises for sawing of logs into boards to meet part of their requirements.

The sawn material received in the factory, as well as the material sawn in the factory premises, is properly seasoned before it is used. The dimension stock, such as half-wroughts of legs of chairs and tables, are usually air-seasoned in a seasoning shed. The sawn planks are either air-seasoned prior to kiln drying or they are kiln-seasoned from green condition. In one factory one inch thick oak planks were dried green from the saw in four weeks in the modern internal fan kilns. Birch and beech boards of the same thickness took three weeks for thorough seasoning.

Manufacture.—Most of the operations are mechanically carried out in large factories, which suits the mass scale production. The seasoned wood is first planed, then cut into sections of proper sizes for different articles. The components so obtained are then passed through various machines for thicknessing, grooving, moulding and other operations, after which they are taken to the assembly section. The different components of the article are then placed in position in iron clamps, which are mechanically operated, and the finished table or chair comes out. Superior quality articles are assembled by hand. In case of very high class furniture almost all the manufacturing operations except initial planing and cutting are done by hand by highly skilled carpenters.

One big English furniture factory, said to be the biggest furniture workshop in the world, has several mechanical devices for the movement of semi-finished and finished product from one section of the factory to another, besides the usual wood working machines. These consist of moving platform and endless moving belts. In this factory it was interesting to see the semi-finished furniture passing through a drying tunnel on the moving platform on its way to the polishing shop from the assembly section.

(c) Aircraft propeller blades

General.—The techniques of seasoning wood and manufacture of several types of aircraft propellers were seen in America. Birch is considered to be the best timber for this purpose, though maple is commonly used.

Seasoning.—The timber usually comes to the factories as sawn planks, about 1″ in thickness. These are stacked in air seasoning sheds on trolleys for the convenience of movement of timber from the sheds into the seasoning kilns at a later stage for completing the drying operation. Sometimes the stacking of timber is done in the open air also, if there is no space in the seasoning sheds. Great care is taken in making the stack of timber for air seasoning. In order to keep the battens in vertical alignment in the stack, spacing racks are used. These are big panels of wood with grooves properly spaced, fixed on two sides of the stack being made.

After the timber has been air seasoned for about six months it goes to the seasoning kilns for completing the drying operation. The kilns used are of the modern internal fan type fitted with track, trucks, automatic recorder controllers and in some cases with direct temperature reading potentiometer for checking the temperature readings inside the kilns.

Manufacture.—The seasoned timber goes to the sawmill attached to the factory where it is marked for defects, cut into pieces of proper size, about $5' \times 4'' \times \frac{3}{4}''$, avoiding the defects, which are then planed. The selected pieces are later taken to the gluing room, where they are made into blocks of wood using synthetic glue. The glued pieces are pressed together by means of hand clamps, and the blocks so formed are hung with clamps on in an air conditioned room for two days for setting of glue. The clamps are then removed, and the half-wroughts of propellers are conditioned in another room for 3 or 4 days at 100° F., 60% relative humidity for equalization of moisture in timber. The heating and humidification of the room is done by means of steam, using automatic recorder controllers. The half-wroughts are then shaped, first on machine, later by hand, by highly skilled workmen with the help of templates. The propellers are then sand-papered, given several coats of synthetic varnish, and finished. For the purpose of drying the varnish, the blades are put one by one into the notches made in a vertically moving endless belt, mounted in a heated gallery. The blades get dried in one cycle of movement which may take about 10 minutes. The blades are then packed and sent out.

Five feet long blades used in civilian aircrafts were sold for 70 dollars, approximately Rs. 240/- (1948), per piece.

Small light blades used in helicopters, are made of four plies of solid wood—two of sitka spruce and two of balsa. The manufacturing operations are the same as described above. The semi-finished blades are coated with synthetic varnish followed by a coating of water-proof fabric, after which another coating of varnish is given.

(*To be continued.*)

EVERGREEN, MONTANE FORESTS OF THE WESTERN GHATS OF HASSAN DISTRICT, MYSORE STATE—(*concld.*)

A Contribution to the Ecology, Plant Geography and Silviculture of the Western Ghat Forests of Mysore

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SECTION 10.—*The Relation of the Ecological Conditions to the Habitat Distinctions in Evergreen Forest.*

125. During my fairly long experience of the evergreen ghat forests of Mysore I have carried on some instrumentation which, though meagre, gives some evidence as to the degree and manner in which the climatic conditions within the forest depart from the normal conditions of the open country, and tried to determine what the conditions are whose differences are probably responsible for the distinction in the habitats that have been described. The results of the observations made and experience gathered by me in the ghats of Shimoga and Kadur districts have been checked up with respect to the ghat forests of Hassan district before arriving at any final conclusion with regard to them.

126. Even a casual visit to the region enables one to realize that the most salient characteristics of the vegetation are determined by the high rainfall concentrated to a very pronounced wet season (see rainfall graph, figure 1) accompanied by a very long dry season with low percentage of cloudiness and all the subsidiary conditions of dry soil, dry atmosphere, high percentage of isolation and the like which follow. Furthermore, the high relatively dry wind of a hot summer is one of the most important conditions for determining the diverseness of the several habitats.

127. The great contrast between the rainfall of the different seasons rules out the possibility of the soil being very moist throughout the year. Added to this, the evaporating power of the wind which blows at a high velocity and is fairly dry in summer has a strong dessicating effect upon the soil and vegetation. So unequally distributed is the rainfall, so great is the evaporating power of the strong, fairly dry, summer wind, so broken is the vegetational covering and consequently so dry is the soil in exposed situations—ridges and hill-tops—that the differences in the conditions of humidity and ardity are driven to extremes in the different habitats of the rain forest area.

128. So great is the contrast in the ecological conditions reigning within and without the evergreen forest (in naturally exposed situations) that they are best discussed under two separate heads namely :

A. The high-forest of the valleys, ravines and their adjoining slopes.

B. The low, open growth of the tops of spurs, ridges and the bare or grassy hill-tops.

A. *The high-forest of the valleys and ravines.*

129. The factors* which strike one on entering the forest are the struggle for light, the competition for space and the high humidity of the atmosphere. To these must be added a fourth, edaphic, factor namely, the abundance of dead and rapidly decomposing, moist plant residue on the soil.

130. *The struggle for light.*—This is most pronounced, as all available light space is occupied by the green parts of plants and hardly a ray of light reaches the soil in the denser portions of the forest. This struggle finds expression in the great concentration of climbers and epiphytes wherever small natural openings of the canopy exist, and the climax is reached along water courses where, sometimes, the lianes and canes form an impenetrable tangle preventing human progress through it. The lianes and epiphytes are, probably, the true victors in the struggle for light, because, with minimum expenditure of material they acquire the most advantageous position with respect to this factor.

* "The Evergreen Ghat Rain Forest, Agumbe-Kilandur Zone", Indian Forester, April 1941, page 16, by Dr. Krishnaswamy Kadambi.

131. *The competition for space**.—This arises owing to the great wealth of species and individuals which throng the space between the top level of the canopy and the ground surface ; and for this the favourable growth conditions of the evergreen zone are responsible. The space available for the green parts of plants above the ground is considerable, as the highest layer of the canopy stands a hundred feet from the ground. The space below the ground is, however, quite meagre as, inspite of stature of the tall trees above the earth, their root system is generally shallow and the ground is often quite steep. Root competition among the plants is necessarily severe and, if the canopy is unduly opened up and the large trees isolated, the effect of wind on them can become disastrous.

132. *The humidity of the atmosphere**.—The air is humid under the evergreen canopy practically at all times. In the rainy season the humidity does not swerve for days together from the saturation point, as precipitation is almost continuous and saturation must precede precipitation. The constant passage of the rain-bearing clouds and the cloudy mist over the face of the sun causes immediate and pronounced rise in the humidity which never falls owing to the continuous stream of a mass of cloud passing overhead and in-between the trees. From the experience of my continuous stay close to the head of the Agumbe ghat for nearly three years, and my constant visit to the windward slopes and valleys at all seasons of the year, I may hazard the estimate that during the greater part of June, July and August the forest is enveloped in cloud for almost 100 per cent of the day light hours, during September for about 30 per cent, and from mid-December to mid-March 5 to 10 per cent. The nights are generally clear in December, January and early February, and lower humidities occur then by night than those prevalent during day. It is also the season when relatively the greatest wind-stil prevails over the rain-forest region. This is, therefore, the season of probably the lowest air humidity. By the third week of February the conditions are all changed. The temperature rises by day, practically to its top limit of the year, March being the hottest month.

133. I have almost every day watched the Arabian sea during summer from various points of the crest of the Agumbe ghat and noticed that one or two hours after the sun crosses the horizon to the west a solid column of cloud rises and gathers in diverse and irregular shapes over the Arabian Sea. By the middle of March detached fragments from this cloud mass are continually blown across the main ghat ridge. During this season also, the hot sun, by evaporating the water from the free surfaces and greatly increasing the transpiration from the myrids of leaf surfaces, causes a continuous stream of vapour to ascend from the bottom of the valleys up the slopes, which increases the humidity of the atmosphere; this moist heat is felt in the valley when one descends the Ghat on a warm sunny afternoon to the elevation of 800 feet and under.

134. I am not able to give any figures or records to show exactly what difference there is between the moisture conditions at different altitudes on the windward slopes, but I am certain that the humidity is very high in the valleys. This moisture is precipitated in the early morning hours every day when the temperature falls. The climatic and topographic conditions in the valleys and ravines facing the sun join with the sheltering effect against wind and the islolation of the forest itself and its immense evaporating surface, to give to this habitat conditions of moistness which can hardly be exceeded in any locality. The ridges, on the other hand, are exposed to air movements which prevent the attainment of the highest humidities and accelerate the drying of the natural evaporating surfaces of the forest. In the ravines and valleys on the other hand, the evaporation rate is constantly low and fluctuates little. I am unable to give correct figures owing to want of an atmometer, but I can state without hesitation that the rate of evaporation to rainfall in the ravines is probably very low even taking the whole year into consideration.

135. *Air temperature.*—No accurate records of temperature within the forest itself exist, but it is known that the windward valleys and ravines exhibit the lowest ranges of temperature and those of the slope, the ridge and perhaps, the forest canopy are greater but not very

* Compare *Schimper, A.F.W.*, Pflanzengeographie auf Oekologischer Grundlage.

different from the ravines. These slight differences in temperature are, however, without significance in the differentiation of the habitat within the rain-forest, and they are of importance only in so far as they operate conjointly with other factors affecting transpiration and growth. The differences in temperatures are of little or no significance in the limitation of species.

The soil moisture and the well balanced water-household of the evergreen forest.

136. It has been shown in the preceding paragraphs that the distribution of the annual rainfall is very irregular, and that whereas between the middle of June and end of August torrential rains pour almost incessantly from a constantly over-clouded sky which may entirely shut out the sun, there follows for seven months between October and May a period of little or no rain. The metabolic activity of the rain-forest vegetation is carried on, more or less uninterrupted, all the same, and the forest retains its essestially evergreen character throughout the year. Inspite of the rainfall being seasonal and short, though very heavy, many forest streams remain perennial and this is so although the ground is very steep, and often precipitous, because the dense forest cover prevents the rapid run-away of the rain water. This water which descends into the soil during rainy season percolates gradually through the ground and keeps the surface soil in the valleys, ravines and slopes adequately moist for the growth of the roots, and all the excess emerges to the surface to feed the innumerable perennial streams.

137. There are, also, other factors which conserve soil moisture. The heavy soil cover of distintegrating organic debris and the large number of hygrophyllous musci, lichens, other hepaticae and pteridophytes and the velamen covered root system of the higher plants are probably capable of absorbing moisture directly from the humid amtosphere, while the first, in addition, obstructs any undue evaporation from the ground surface.

138. Another direct source of water for the forest even during the dry season exists. It has been pointed out in an earlier paragraph and in a previous paper* by me that there occurs in summer, precipitation of moisture from the air during the early morning hours, and that this is sometimes fairly heavy, and amounts to what one would look upon as a miniature rainfall of the mixed-deciduous (Moist deciduous-Champion) forest zone. This precipitation is sometimes heavy enough to render the whole forest floor fairly moist, and it is likely that the hygroscopic soil covering of the decaying plant debris has a role to play in absorbing this moisture with eagerness.

139. A further source of moisture for the evergreen forest in the dry season is the moist, cloud bearing premonsoon wind from the Arabian Sea. Standing on a summer afternoon at the head of the ghat overlooking the Arabian Sea one sees in April and May masses of cumulus and nimbus formation fragmenting and being carried over by the wind across the ghat and, with the approach of evening, a moist fog hangs over the western sky. This source of moisture is also of importance in providing that water which is eliminated from the forest air owing to the lowering of temperature during the early morning hours.

140. Finally, the evaporation of water from the free water surface of the perennial streams as well as the water of transpiration from the exceptionally large leaf surface of the forest and the wet organic debris of its soil during the hot summer afternoons contribute to replenish moisture in the atmosphere of the forest zone; and the stifling moist heat which one experiences at the bottoms of valleys and in ravines during the sunny afternoon hours is an indication of the high humidity reigning in the forest.

141. Thus, inspite of the prolonged dry season the evergreen forest maintains a well balanced water-household, and this is rendered possible by various conditions, most of them created and encouraged by the forest itself.

The dead and rapidly decaying organic debris.

142. The role played by the organic debris which is constantly replenished by the branches and leaves returning to the earth has already been referred to. This is, in a large measure, responsible for the fertility of the upper soil layers and, in some places, enables the forest soil, though relatively shallow, to

* The Evergreen Ghat Rain Forest of the Tunga and the Bhadra River Sources, Kadur District, Indian Forester, June 1942, page 2, by Dr. Krishnaswamy Kadambi.

maintain the luxuriant forest by directly contributing the nitrogenous material so essential for growth. It plays also no insignificant part in regulating the water-household ; on the one hand it absorbs moisture directly from the water-saturated forest air ; on the other its porous surface gives up water readily during the dry day hours when there is a saturation deficit, thus preventing the atmosphere from getting unduly dry and harmful to the hygrophilous plant life.

143. During the rainy season, the heavy humus layer prevents surface erosion on the steep gradients, and checks the rapidity of the down-flowing water.

144. The activity of bacterial life which it harbours contributes to the warmth necessary for a ready distintegration of the organic debris.

145. This organic debris rapidly disappears on removing the forest cover and with it the soil gets rapidly impoverished ; and when the forest is no longer there to replenish the plant debris removed by disintegration, the fertility of the soil cannot be rebuilt. In other words, the evergreen forest is largely responsible for creating and maintaining its own fertile soil, and the two—the fertile soil and the forest—are supplementary to each other.

Variation of micro-climatic conditions within the evergreen forest.*

146. The micro-climate of the evergreen forest varies considerably. The mean daily range of temperature in the soil substratum is very low and has been determined to be 2° F. by Forrest Shreve in the Blue-mountain range of Jamaica. The difference of soil temperature between forested soils of windward ravines and open slopes of leeward side was found to be 10° F. I have observed in March a difference in the air temperature of 30° F. between the open and the shade of the evergreen forest. Within the forest, there exists during most parts of the day, even in the dry season, an atmosphere charged with water vapour. The vegetation is hygrophilous. At the top level of the crowns, on the other hand, there exist during the dry season, xerophytic conditions.

147. The sun, during summer, pours a nearly uninterrupted flood of light and heat on the tree tops which, when viewed with a pair of binoculars from an opposite vantage point, throw back the light from the millions of glistening leaf surfaces. A strongly developed cuticular layer, stomata sunk under the leaf surface to prevent excessive transpiration and a well developed palisade tissue are characteristic features of these leaves. Those underneath the canopy, on the other hand, have the anatomy of typical shade leaves. The epidermis is thin, with meagre cuticle, and there is a poorly developed palisade tissue, well developed spongy mesophyll with abundant interspaces and raised stomata†. Even the size of the leaf shows variations, trees standing under the main canopy having larger leaf surface than those which are at the top.

148. As already mentioned, the epiphytes within the forest are strongly hygrophilous ; they shrivel and dry up on exposure to direct sun within a very short time while those in the crowns are provided with water storage organs, very thick cuticular layers and reduced leaf surfaces. The contrast between the epiphytes of the lowest level of the forest and those at the tree tops provides striking evidence of the greatly varying micro-climatic conditions between the level of the forest floor and its crown.

149. There is also a certain amount of difference between the epiphytes found at the crown level of trees in ravines or valleys and those on the ridges or tops exposed to the western wind. The dessicating effect of the accelerated transpiration combined with the mechanical force of the high wind reduce some of these epiphytes into dimunitive size and enhance their power of anchoring themselves on the stems and branches.

B. *The low, open tree growth of the tops of spurs and ridges and the bare or grassy hill-tops.*

150. This entire formation presents a striking contrast in form, stature and composition of species to the valley forest ; and indeed the differences between them are so great that points of comparison are few.

151. *Rainfall.*—It is true that both the habitats enjoy the same or nearly the same amount of rainfall but while in the case of the valley forest this water is conserved and nicely

* Observations on the Growth of Poeciloneuron indicum, Indian Forester, April 1938, page 219, by Dr. Krishnaswamy Kadambi.

† Observations on the Growth of Poeciloneuron indicum, Indian Forester, April 1938, page 218, by Dr. Krishnaswamy Kadambi.

distributed all round the year, the same water runs rapidly down the open ridges and tops leaving them high and dry in a very short time. Some of it sinks into the soil to saturation but this soil is, in most cases, so shallow and the sub-soil, which consists of sheet rock, so completely impervious that with the return of sunny weather the soil gets bone-dry in a very short time ; and to this dessication the radiating heat of the overlooking bare rocks whose dessicating effect by day is enormous only adds.

152. *Soil.*—This presents a striking contrast to that of the valley. There is little or no humus here, and it is generally grassy, shallow, lined below with impervious sheet-rock and unprotected above by any tree growth, if not covered with a semblance of one. The accumulation of plant debris is not possible owing to the heavy wash-out to which the bare soil surface is exposed in the rainy season, or this debris is disintegrated by the fierce sun of summer and burnt away by the recurring grass fires.

153. *Humidity and high wind.*—The air is humid during the rainy season but its salutory effect upon the vegetation is counteracted by the fierce impact of the wind which blows predominantly from the western direction during the year and, during the dry season when the wind is also relatively dry, its dessicating effect consequent on its rapid movement is enormous. This, combined with the physical force exerted by wind and the scortched shallow soil with its totally impervious sub-soil rock create a set of conditions so unfavourable to plant life that none but the most hardy among them can manage to live.

154. *Temperature.*—This is necessarily very high compared to the interior of the ravines and valleys. There is often not a speck of shade interrupting the sun who pours from his place in the high heavens a warm ocean of light which heats up the often absolutely bare rock, and the rock in its turn radiates the heat into the surrounding area, adding to the unfavourableness of the situation. This is by day. By night, on the other hand, the temperature falls considerably owing to the unimpeded radiation of heat from the rocks and the blades of grass, and it sinks probably far below the temperature under the canopy of the valley forest. I have had opportunities to camp out on these open ridges and tops and also underneath the canopy of the evergreen forest in valleys, and I have found that in the former situation it is very cold by night, while in the latter it is tolerably warm. The wind of the former situation adds greatly to the discomfort. The lowest temperature recorded on a February night was 55° F. in the open, while it was 64° F. within the forest.

155. *Floristic composition.—There are few localities on the earth placed so close to each other yet differing so greatly in their floristic composition as the evergreen high forest of the valleys and their adjoining ridges and tops.* The valleys contain an assemblage of plants which, in stature, diversity and wealth of species and individuals, is of the most luxurient which nature has produced in the tropics, while the assemblage on ridges and tops consists of species so few in number as to be countable at our finger's ends, of individuals which stand few and far between, and of a stature by which the tallest tree can hardly boast of a clear bole. The tree species here are mostly natives of the mixed-deciduous zone, and consist of individuals which are stunted, crooked and gnarled, generally without a bole or anything like a well developed crown. There is nothing like a tree canopy as the stems stand few and far between. There is also a tendency for them to develop a shrubby form, with leaves of reduced size and tough texture. Among them may be seen stunted specimens of *Terminalia tomentosa, T. chebula, T. belerica, Lagerstroemia lanceolata, Bridelia retusa, Dalbergia latifolia, Eugenia sp., Gardenia sp., Ixora sp., Plectronia didyma* and, very commonly, shrubs of *Wendlandia notoniana*. There is also a tendency to the formation of groups or colonies for ferns, where they exist. The commonest is the Bracken-Fern (*Pteris aquilina*) which, with its powerful subterranean runners, covers large areas while, occasionally, tufts of *Gleichenia dichotoma* are also found. The ground is covered by high grass amidst which the hardy, fire-resistant *Phœnix humilis* occurs sprinkled with its often prostrate stems.

156. *Fire.*—The grassy tops and ridges are visited by annual fires which, encouraged by the high wind, sweep across them till they reach the edge of the evergreen growth, which they occasionally singe as they break themselves against it. The typical evergreen forest

of the valleys is not inflammable during any part of the year and fire, even wilfully kindled, is incapable of spreading but is soon lost in the moist debris.

SECTION 11 :—*Seasonal behaviour of the rain forest vegetation.*

157. The presence of the organs of photosynthesis, namely the leaves, does not necessarily mean that the matabolic activities of the evergreen forest plants continue at a uniform pace throughout the year. The great diversity in the rainfall from season to season, the long and pronouncedly dry weather at one time of the year and the superabundance of moisture at another make the evergreen growth react in a characteristic manner. In the rainy season torrential rain pours almost incessently, the sky is constantly over-clouded and the temperature falls considerably. A glance at the temperature curve of Kadamane (figure 2), a recording station situated in the midst of the evergreen forest, shows that during the rainy months (June to August) the maximum (monthly mean) temperature is lower than in the winter months (November, December and January) by nearly 10 degrees Fahrenheit. The atmosphere is surcharged with humidity and this, combined with the relative lack of warmth, probably hinders transpiration. Photosynthetic activity remains at a low ebb owing to want of direct sun-light and the ground surface is often flooded with water thus impeding the normal respiration of the root system. In other words, conditions are really unfavourable for vegetative activity, although they apparently are very favourable owing to abundant rainfall. In contrast to mixed-deciduous forests, where the rainy season is the season of greatest vegetative growth, in the evergreen forest there is a pronounced lull in growth. Few flowers or little fresh leaf is seen during this season. September, especially its latter portion, has relatively less rainfall, greater warmth and sunlight, and this condition continues, with gradually decreasing rainfall almost till the middle of December. This period from September to December is the time of the most pronounced growth. The maximum amount of young leaf, especially among the forest undergrowth, is seen during this period.*

158. This is followed by the flowering season, dry and warm, of December, January and February, and then by the season of early fruit of March, April and May. The premonsoon

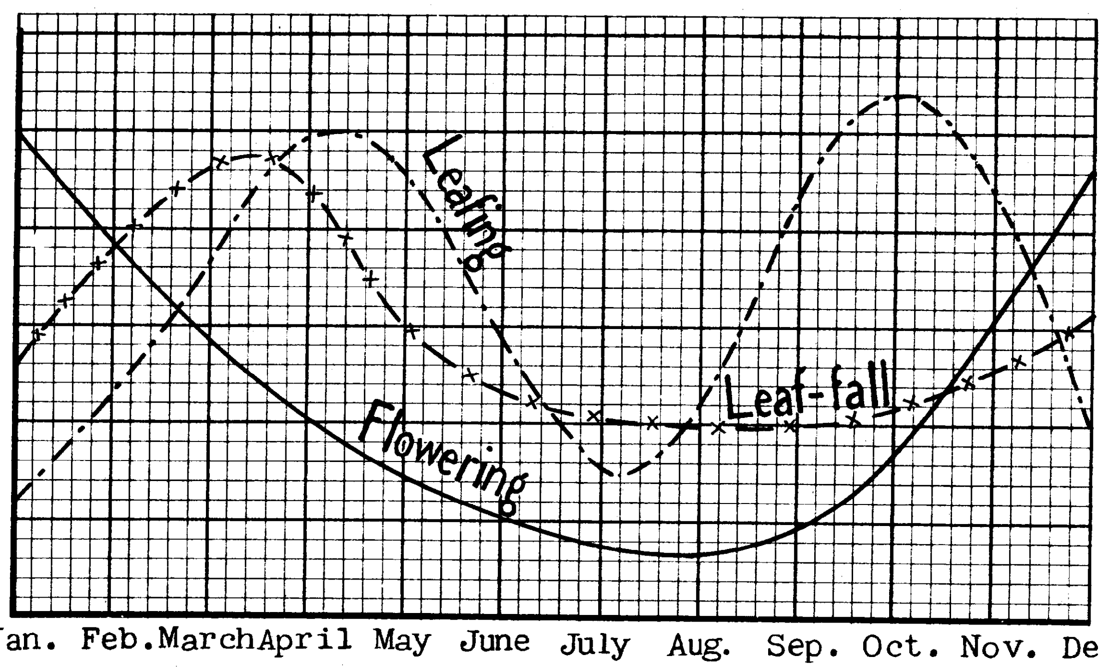

Figure 3.

* See graph under paragraph 158.

showers of April usher in a second, but shorter, period of vegetative activity in April and May, which comes to a standstill with the commencement of the south-west monsoon in June, and the forest remains in this condition till again the relatively dry conditions of September return. During the premonsoon period, a good number of herbs and shrubs flower though all important tree species are then in early fruit. There are thus two seasons of vegetative activity, a longer one following the rainy season and a shorter one preceeding it, whose continuity is marred by the season of reproductive activity—flowering and fruiting. The curves above indicate the general tendency of the rain-forest vegetation taken as a whole as regards leafing, flowering, and fruiting. The curves do not apply to individual cases.

The period of maximum vegetative and reproductive activity corresponds to the relatively drier and driest portions of the year respectively.

159. It should not be thought, however, that during the other seasons, excepting probably the rainy one, there will be no flower or fruit in the forest. The number of species and individuals in the evergreen forest is so large and the ecological conditions so diverse from place to place that fresh flower and leaf is seen in limited numbers all the year round except, probably, during the heavy rains; and some members of the undergrowth, especially those which enjoy a relatively uniform climate, may be found in flower all round the year. The periodicity in flowering and fruiting is most conspicuous for the tree species, and especially those of the top canopy level.

160. *Leaf-fall* :—Even the statement so often made that in the evergreen forest there is no pronounced leaf shedding season is only partly correct. The onset of the dry season in December is accompanied by heavy shedding, though not complete shedding as in mixed-deciduous forest, but there is little doubt that the thinnest clothing of foliage is found upon the trees during the dry time. This is followed by flowering during which afoliation is not so evident, but soon after it considerable amount of leaf growth takes place.

161. The inherent periodicity of the species whose natural habitat is the mixed-deciduous zone is not lost by their occurrence in the evergreen zone, the only influence excerised by the evergreen forest on them being probably the shortening of the leafless period.

162. The deciduous tree species, of the genera *Holigarna*, *Sterculia*, *Bombax*, *Stereospermum*, *Hymenodictyon* and some others, shed their leaves in December–January although the rest of the forest remains green during the dry season, and the flowers appear, as usual, when the trees are practically leafless. The new leaves start as the flowers drop and the fruit is in formation, and the trees are in full leaf again when the rains start. New shoots are put out from September onwards till the tree prepares itself once again for the ensuing dry weather shedding.

163. The early sprouters of the mixed-deciduous zone, among which *Schleichers trijuga* is well known for its copper coloured leaves, behave here in a very interesting manner. They are never completely leafless, and yet retain their periodicity of leafing unchanged, so that their copper coloured leaves emerge conspicuously at the height of the dry season and provide a welcome, prominent colour contrast to the rest of the evergreen canopy, much as they do to the brown, leafless trees of the mixed-deciduous forest during summer. *Canarium strictum* has, also, its chief leafing season in the middle of summer.

164. *Flowering and fruiting.*—The principal flowering season lasts from the middle of December to the middle of February, the height of flowering being in January. This is followed by the time of the young and the ripe fruits from March to June or July. A second, though less conspicuous, period of fruiting is seen in November–December.

165. The members of the undergrowth, however, flower for a much longer time in the year, and they may be seen in flower practically at all seasons, excepting the rainy one. Prominent among such are *Psychotria truncata*, *P. dalzelii* and other members of the rubiaceæ which form the undergrowth of the evergreen forest. The pteridophytes, among which are a host of ferns, bear their sori in the months following the rainy season, especially in November and December, while liverworts, mosses and fungi bear their abundant sporophores and other organs of fructification still earlier.

The majority of the members of the epiphytic vegetation flower along with the larger tree

species in the dry season and bears fruit soon afterwards.

166. Notes on fresh leaf, leaf-fall, flowering and fruiting.

Species, genus, etc.	Fresh leaf, or peak of vegetative period	Leaf-fall	Height of flowering	Ripe fruit or reproduction
Bryophytes—Liverworts, Mosses and *Fungi*	Rainy season—June to September	..	..	September-October
Pteriodophytes—Ferns	May to October, with a short break in the rainy season.	..	..	November-December
Phanerogamic epiphytes ..	September to December	January-March	January-February	May-June
Actinodaphne hookerii	December-January	Summer	March-April	June-July
Artocarpus hirsuta	..	December	January-February	May-June
A. integrifolia	..	December	December-January	May-June
Bombax malabaricum	March	January-February	January-February	April-May
Calophyllum elatum; C. wightianum	..	..	February-March	May-June
Carnarium strictum	..	..	..	December-January
Cedrela toona	January-February	December-January	January-February	April-May
Cinnamomum (2. spp.) ..	March-April	..	February	May-June
Dichopsis ellipticum	April	March	January-February	May
Dipterocarpus indicus	April-May	March	December-January	May
Dysoxylum malabaricum ..	April-May	February-March	February-March	June-July
Diospyros spp.	..	..	January-March	June
Elæocarpus spp.	February-March	December-January	January-March	May-June
Eugenia spp.	..	..	January-February	May-June
Gordonia obtusa	..	..	February	June
Garcinia spp.	..	..	March	June-July
Holigarna spp.	..	December	January	April-May
Hopea spp.	..	..	January-February	May
Kingiodendron pinnatum ..	..	..	January-February	May-June
Lagerstroemia lanceotata ..	..	March	April-May	December
Litsea spp.	January-February	December-January	March	June-July
Lophopetalum wightianum ..	..	..	February-March	June-July
Mesua ferrea	January-February	December	March-April	June-July
Myristica spp.	..	..	March	June-July
Poeciloneuron indicum	January-February	December	March-April	June-July
Sapium insigne	March	December	February	April-May
Sterculia guttata (Roxb.) ..	February-March	December-January	February-March	December
Schleichera triiuga	February-March	..	February	June
Vateria indica	.	March	March	June

SECTION 12.—*Germination and establishment of seedlings in the evergreen forest.*

167. It has been made clear in the preceding paragraphs that there exists great climatic contrast between the interior of the evergreen forest and its uppermost crown level and that, while in the interior there is little light, great humidity, relative wind-stil and uniformity of warmth, the uppermost crown canopy is exposed to the fierce rays of the sun, low humidity, strong wind and greater differences of heat and cold by day and night. The leaves of plants within the forest are therefore necessarily of the shade bearing type. They are thin, relatively large with little protection against transpiration, while those at the level of the crowns are smaller, thicker, tougher and provided with strong cuticular layers. The mineral soil which the radicle of a germinating seed seeks for its establishment on emerging from the seed coat is not readily available on the evergreen forest floor owing to the presence of a thick layer of organic debris which is packed upon it. The radicle has, therefore, the task of first penetrating this layer before reaching the mineral soil which is its source of nourishment and, inspite of the abundance of seeding, a considerable proportion of the germinated seed dies away unable to reach this soil in time. This factor also accounts for the fact that where organic debris has been removed, either artificially or by natural disintegration as a result of a break in the canopy, the forest floor will be found full of seedlings of the tree species. Not infrequently the surface of forest extraction paths is covered with multitudes of seedlings whose abundance astonishes those who see them. In the ensuing summer, a good number of these seedlings which are directly exposed to the sun perish owing to drought.

168. The need for penetrating the organic debris is answered by many of the tree species in the development of a long, well grown root system very early in their life, and *in this respect the evergreen forest plants behave similarly to those thriving in the xerophytic zones, where also the seedling is compelled to develop often an unduly long taproot very early in its life in search of sub-soil moisture on which its existence depends.* Thus, external conditions very different from each other have yet produced similar results in the two instances*. The plumule generally remains under-developed until this establishment of the root of the seedling takes place in the soil.

169. Light is another important factor, next to mineral soil, on which the young seedling depends, but all evergreen species are able to get only a very limited amount of it inside the forest. The regeneration of all species has to thrive in shade and it is well adapted to this necessity. The seedlings possess remarkable power to tolerate shade and to withstand the keen competition for light and space in the interior of the evergreen forest. Once the root system has anchord itself in the mineral soil the seedling acquires a tenacious power to face suppression for an indefinitely long time and responds to the influx of light even after suffering years of continued suppression. Many important evergreen forest trees are provided with large cotyledons or endospermous tissue storing food material, m‥ch like many species of the xerophytic zones ; the object of Nature in both cases seems to be to provide nourishment for the development of a powerful root system which can anchor the plant to the mineral soil in the evergreen forest or penetrate to the subsoil layers in search of moisture in the xerophytic zones. The genera *Poeciloneuron*, *Palaquium*, *Dipterocarpus*, *Mesua*, *Canarium*, *Myristica* and *Garcinia* are important examples of seeds with ample nourishment in them.

170. In contrast to the seedlings which are strongly shade tolerant, *the saplings and poles of evergreen species, especially those which are found in the top levels of the forest canopy, are strong light demanders.* They suffer badly when over topped or suppressed, and merge into a state of stagnation in which there is little annual growth. They are, however, able to persist in this condition indefinitely long and benefit again by any influx of light, unlike the light demanding species of the mixed-deciduous zone which die sooner or later when subjected to continued suppression.

SECTION 13 :—*The progress of natural regeneration.*

171. This, of all the important tree species which dominate the top canopy, is generally adequate to replace the loss by natural death or uprootal by wind. Except in the very dark portions where little sunlight reaches the

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* The Evergreen Ghat Rain-Forest, Agumbe-Kilandur Zone (Indian Forester, April 1941, page 19), by Dr. Krishnaswamy Kadambi.

forest floor, the soil is generally covered with a mixture of young growth of the tree species in all stages of development which is not readily visible owing to the abundance of undergrowth. Even at spots where owing to sudden influx of light a host of fast growing, light demanding weeds are found crowded together, careful observation reveals underneath them a good number of seedlings and saplings of the larger tree species. *In places where the canopy has been disturbed by forest exploitation promiscuous natural regeneration comes up and replaces the light-loving weeds which first set foot on the soil.*

172. *A judiciously worked evergreen forest is therefore better regenerated by nature than one in its virgin state.* In other words, it is only necessary to exploit an evergreen forest to obtain abundant natural regeneration. In the evergreen zone the problem is not one of obtaining but of *securing* and *tending* the regeneration *of the right kind*—the desired species.

SECTION 14.—*Rate of growth in the evergreen forest.*

173. This, contrary to probable expectation, is generally slow in the evergreen forest. Owing to the favourable growth conditions—moisture and warmth—over the major portion of the year, there is no concentration of growth in any period, and this is quite unlike the temperate and arctic regions when the onset of spring ushers in a period of feverish vegetative activity, and the whole vegetation bursts into growth and continues its very rapid development for a short time in the year. In the drier zones of the tropics, again, it is not the cold but the drought which sets a limit to the duration of the vegetative activity, and the onset of moist weather brings with it renewed vegetative growth, which lasts for the duration of the monsoon.

174. The distribution of vegetative growth during the major portion of the year is probably responsible for the relatively slow rate of growth in the evergreen zone. Lock* found the rate of elongation of the giant bamboo, *Dendrocalamus giganteus,* in Ceylon to be 231 m.m. per day; Maxwell†, has recorded a rate of growth of 107 m.m. per day in the growth of banana leaves. Schimper‡ measured the leaves of *Amherstia* and found the rate of growth to be exceedingly rapid. The rate of growth of *Bambusa arundinacea* culms which emerge at the beginning of the south-west monsoon after the clumps have been stimulated by a fire is extraordinarily rapid, and rates of elongation from 3 to 4 inches a day are not uncommon.

It is natural to anticipate differences of rate between plants in the rain-forest itself in which the growth is continuous and those in which it takes place during only a few months or weeks in a year. The larger tree species of the upper canopy belong mostly to the former group, while the seasonal herbaceous plants belong to the latter. For instance the elongation of leaves of the tree ferns *Alsophila* and *Angiopteris* takes place just after and just before the season of the heaviest rainfall, and their elongation is probably among the fastest in the evergreen forest. So also the leaves of the wild plantain and the wild *Amorphophallus* are very fast growing. Marked branches of several trees of the tree species have been kept under my observation for two years, notable among them being those of *Mesua ferrea, Hopea parviflora, Dipterocarpus indicus* and *Poeciloneuron indicum,* but none of them exhibited growth which could be called rapid.

It is the rhizomaceous plants—usually herbs and shrubs and probably a few climbing palms—which grow quite rapidly, and this is partly due to their being seasonal ones.

175. The relatively slow growth of the evergreen forest plants is, also, probably due to the high humidity which retards transpiration. Although no exact reciprocal relation between the growth rate and the average transpiration rate of plants has been, as yet, established, there is every reason to believe that the low rates of growth exhibited by evergreen forest plants are occasioned by the low rates of transpiration due chiefly to the prevailing high humidities§.

SECTION 15.—*The influence of light on the growth and form of trees in the evergreen forest.*

176. The stately form, height and cylindricity of the bole of many trees in the evergreen

* Lock, R. H., On the Growth of Giant Bamboo, Ann. Roy. Bot. Gard. Peradeniya, 2, Pt. 2, August 1904.
† Maxwell, W., The Rate of Growth of Banana Leaves, Bot. Centralb., 67, 1896.
‡ Schimper, A. F. W., Plant Geography, Oxford Edition, 1903.
§ A Montane Rain-Forest (published by the Carnagie Institution of Washington, 1914), by F. Shreve.

forest is influenced to a considerable extent by the keen struggle for light among trees in their sapling and pole stages. The depth of soil or its fertility cannot by themselves account for the great heights which the taller trees reach, because the forest grows in many cases upon soil relatively shallow, but, I think, the early demand for light of the saplings plays a great part. Owing to the abundance of vegetation the saplings and poles live under constant congestion, and the only way open to them for relieving themselves of this hemming in is upwards into light. The trees join in this upward race very early in their life, their apical growth is pushed forward uninterruptedly and the crown assumes a pyramidal form which is retained indefinitely long, until it reaches the top level of the forest canopy.

177. *General conclusions.*—The ghat forests of Hassan present typical tropical evergreen montane rain-forest conditions with their windward west wall of 2,000 feet height exposed to a relatively short but extremely rainy season followed by a very long, partly rainless dry season. There are interesting changes in the vegetation between the low lying land of South Kanara about 500 feet above M.S.L. and the Mysore Plateau about 2,000 feet above the sea. The growth is practically in its virgin state, uninterfered with by man. On the tableland adjoining the western wall, however, human interference is considerable, and several coffee and cardemom estates and paddy lands have broken up Nature's uniform forest cover. From about 2,500 feet upwards to about 4,500 feet, which is the level of one of the highest peaks of this area, there is little tree cover, and grassy hills or sheetrock fill the landscape. The rainfall is about 250 inches, and the prevailing vegetation is of the "moist tropical evergreen" type with a floristic admixture of genera in which those characteristic of the "Ghat" country prevail.

178. On both the western, windward *ghat* slopes and the tableland into which these merge, minor distinctions can be made out between the vegetation of the valleys, slopes and ridges. The effect of monsoon rain, excessive humidity and wind are modified by the erosion topography in such a manner as to make the deep valleys the most hygrophilous habitats, the ridges and hill tops the least hygrophilous and the slopes intermediate between these two. The forests of the ridges are essentially alike on both the windward slopes and the tableland, but those of the ridges on the windward and leeward sides are substantially different. The most important physical factor concerned in the differentiation of these is the wind.

179. The windward valleys and slopes exhibit the most striking characteristics of the evergreen forest, some of which are lacking in each of the other habitats namely, the ridges and hill-tops. Each type is so well adopted to its own habitat that it cannot emerge from it; in other words it is not possible to state that the forest in any one of the three regions namely—the deep windward valleys, the slopes or ridges and the hill-tops—alone represents the so-called "climax" forest of the evergreen ghat zone.

The topography is of prime importance for the distribution of the vegetation, for this is the agency by which the physical conditions are given their local modifications, and these modifications are, in turn, responsible for the distribution of forest types.

Under the conditions of equable temperature and abundant water supply which obtain in the forest, no effective climatic checks exist to the almost continuous activity of the plants. Yet, the superabundance of rainfall in the short rainy season and the long, practically rainless season which follows it cause well defined annual periodicities, there being two leafing seasons, which alternate with the very wet season with its least vegetative and reproductive activity and the dry season with its maximum flower and fruit. There is no well marked season of rest like the winter season of the temperate or the drought season of the mixed-deciduous and dry-deciduous forests.

The rate of growth in the evergreen forest does not seem to be faster than in the mixed-deciduous forests, and this is probably due to the fact that growth is not concentrated in any one season of the year. The uncoiling of leaves of tree ferns and some larger herbaceous plants is rapid, but growth is slow in the important timber trees.

The prevailing conditions in the interior of the evergreen forest are inhibitory to transpiration and also to photosynthesis. The high humidities and the paucity of sunlight are probably responsible for this.

The differences between the climate in the interior of the forest and in the forest openings and the differences between the climate at the forest floor and at crown level are great, probably as great as that between widely separated localities. Corresponding with these differences of climate exist striking differences in the character of the vegetation. The leaves at the crown level possess sclerophyllous foliage; the epiphytes at higher crown levels are provided with coriaceous leaves or special water-catching and storing devises, while at the level of the forest floor are found the thin leaves of the larger, herbaceous plants having an open mesophyll of several layers of cells and a thin epidermis through which water can evapoate. *This tremendous contrast, which is due to the vertical differences of climate between the crown and the floor of the forest, depends upon the existence of the forest itself.* The dominant trees and the high level epiphytes are capable of protecting themselves against heavy loss of water to which they would be subjected during the long, rainless period of the year with its cloudless weather, while the hygrophilous plants of the lowest stratum are protected for the full duration of the dry period by the shade in which they are growing and by the humid air fed by the enormous quantities of moisture given up by the soil, the rotting logs, the beds of mosses and liverworts, the litter of fallen twigs and leaves, and the water surface of the perennial streams.

There is no type of vegetation in which a wider diversity of life-forms and no locality in our forest zones where a greater contrast of micro-climatic conditions exist side by side or one above the other than in the evergreen ghat rain-forest. There are, also, great diversities of structure which one can discover in the field, diversities of physiological behaviour determinable by experimental observations, very high degrees of specialization which may be seen under desert conditions both in the establishment of seedlings and adaptation of life-forms. The physiological activities of the evergreen forest are almost continuous all round the year but slow, that of the arid tracts or of colder zones relatively fast but confined to brief periods in the year. In these forests is found, perhaps, samples of the most luxuriant vegetation on the earth and the most diverse forms of vegetable life.

FOREST NEWS

Extracted form Zeitschrift für Weltforstwirtschaft

The International Centre of Silviculture

The International Centre of Silviculture that had been established according to the resolution of the 1936 Forest Congress which met at Budapest was finally dissolved and its assets were transferred to the Forestry branch of the Food and Agriculture Organization. The liquidation was carried out by the Inspector-General of Forests in Switzerland.

Foresters in World Forestry

The following is a general review of trained foresters in relation to forest area in the World :—

50 countries covering 66% of the World's forest area answered the questionnaire on the employment and training of the forest personnel sent out by the FAO. The average area managed by a single person works out to 2,56,993 acres per member of the superior service and 79,075 acres per member of the inferior service. From the information collected it can be gathered that in some countries, like Africa and South America, forestry is being practiced in a very extensive way, and sometimes there is no set up for forest management. There appears to be great need for more intensive forest management.

Every reporting country is trying to increase the number of its forest personnel, and especially that of the superior service. Against a triennial requirement of 7,124 officers, there are 6,921 who will complete their education; Argentina requiring 50 higher and 100 lower foresters ranks first among those countries requiring more forest personnel, then follow Iran and Chile.

The Tenth Congress of the International Union of Forest Research Stations in Zurich

After 12 years interval, the tenth Congress of the International Union of Forest Research Stations met at Zürich between 5th and 11th Sept. 1948. Representatives of 15 European countries of FAO and UNESCO participated. Mr. E. Lönnroth, the president of the Union spoke on the significance of forest in world economics. The General Secretary, Sven Pètrini, reported on the activity of the Union since the last Congress held in Budapest in 1936. On the afternoon of 6th December, Mr. Guilleband, Director General of the Forestry Commission London, spoke on : "The Reforestation Problem in Great Britain". Mr. H. Pallmann, Professor in Zürich, spoke on "The United Action of Paedology and Plant Sociology". On Wednesday, there was a lecture by Professor G. Picarlo, Director of the Poplar-breeding Institute in Casale Monferrato, who spoke about : "The experiences in the cultivation of Poplars". On Saturday the members met for the last time in the technical College. Prof. Benger was elected the President of the Union and Prof. A. Pavari was chosen vice-president. The proceedings closed with a rounding off report and a vote of thanks to president Lönnroth.

World Timber Production

According to the report of the Economic Commission of the UNO the World's output of timber in 1948 already exceeded the pre-World War II output. The European production is lower, but that of the U.S.A. is considerably higher. Also, the import of wood into Europe has greatly increased, even though the requirements of a number of countries have not yet been fully satisfied. Between 1937 and 1947 the share of North America in the World's Timber Production has gone up from 48% to 64%, but that of Europe has fallen in the same period from 40% to 25%. France, during the first 9 months of the year 1948, increased its output of coniferous sawn timber from 317,000 standards in 1947 to 454,000 standards; and Poland from 292,000 standards to 372,300 standards (standard=165 c. ft.).

The Largest Herbarium in the World

The herbarium of the Botanical Institute of the Academy of Sciences in Leningrad is said to be the largest in the World. It contains in its collections over five million herbarium sheets covering the plant kingdom of the entire World. About 40,000 specimens are being added to the collections annually.

The herbarium contains, among others, very old collections of famous botanists, as for

example, that of Dr. Ens (1730–1740), personal physician to Queen Jelisaweta Petrowna, with over 1,000 artistically worked and well preserved sheets. Another valuable collection is that of the private physician to Peter I, by name Robert Areskine, of 1709 which has 180 sheets. The herbarium also contains a collection of dried plants from the tomb of the Pharoha Ramses II, which are now 3,000 years old and still are in a state of excellent preservation.

The damage which the herbarium suffered during the siege of Stalingrad was slight and has been already repaired.

Teaching and Research of Forestry and Timber Economy in the U.S.S.R.

According to the latest reports there are at present in the Soviet Union :—Eleven independent colleges on forestry and timber economy, ten faculties of foresrty in Universities, Technical Collegės or Agricultural Colleges, and fifteen Scientific Forest Research Institutes. All the teaching and research stations are directed from the central "Forest Institute of the Academy of Sciences of the Soviet Union". The number of students for forestry is 3,500 and that for wood industry over 12,000.

Protection of Grain Fields by Trees

According to a Russian Newspaper, the yield of the wheat fields during the last dry season was 50% to 70% higher in areas which have forest growth, than in those where there is no forest. In the steppe areas, the fields of wheat which were provided with a protective ring of tree growth gave double the yield of those without this protection. On this account the Russian authorities have decided that fruit trees or such other tree growth should be planted around wheat fields for wind protection. It has been directed that in treeless tracts 4% to 5% of the area should be afforested ; and this would mean an addition of about 5 million hectares to Russia's forest area.

Utilization of Peat Moors in Russia

Russia is stated to contain about 73% of the world's total area under peat moors. Its utilization was started in 1924 and reached in 1933 already the annual yield figure of about one and three quarter million tons ; it rose to over twenty-three and three quarter million tons by 1937, and the estimated yield for 1950 stands at the colossal figure of forty four million tons. The chief use for peat is in wood deficit areas, as fuel for industrial energy plants. It is certain that peat has an important part to play both in the general economy of the country and in scientific persuits. Peat moors cover immense areas and will provide a source of employment in various ways for decades. Experiments have been carried out to press the peat, and useful products like phenol, creosote, tar and liquid fuel for running tractors have thus been obtained. Peat is also used as litter for cattle.

K. K.

EXTRACTS

ARUNDO DONAX (GIANT REED GRASS) AS A FORAGE GRASS IN SANDY SOILS

(Extracted from Lloydia, Sept. 1948, Vol. II, No. 3)

Arundo donax, a native of the warm regions of the old world was introduced into the United States of America and has spread from California to Texas and further eastward. It commonly grows along irrigation ditches in these areas. The variety *versicolor* is specially favoured as an ornamental plant and it is cultivated on account of its robust and beautiful growth habit.

Its culms are used in America for latices, mats and screens and in Europe for making the reeds of musical instruments like clarinets, saxophones and organ pipes.

Recently the Giant Reed Grass was planted by accident in an exceptionally dry habitat on a partly stabilized sand dune on the Armstrong Ranch, Texas coast. The planting survived

and produced a surprisingly vigorous growth, which is all the more surprising since this species grows best along the moist banks of irrigation canals. It has since become increasingly recognized as a sand binding species in some pasture areas.

Arundo donax is not very palatable to cattle, but during the dry season when fodder is scarce the animals do not hesitate to graze this species. The younger shoots are first eaten and then the upper parts of the older plants. It is therefore apparent that the grass may assume an important place as a forage in dry sandy areas. Its value as a forage for cattle was investigated with the following results :—

1. Nitrogen, phosporous and potassium exhibit the greatest concentration in the upper half of the younger plants.
2. Calcium and magnesium exhibit the greatest concentration in the upper parts of the older plants.
3. Total acid hydrolyzable carbohydrate is greater in the older plants and especially so in the lower half.

(*Arundo donax* is a native of India, both northern and southern. The possibility of its use as a sand binder and pasture grass in our dry and sandy areas is well worth investigating).

Ocimum kilimandscharicum Guerke, Flowering branches from coppice plants.

Photo Author.

Ocimum kilimandscharicum Guerke, age from seed 1½ years, coppiced thrice. Age of coppice 3½ months. Ruderpura (U.P.).

Photo Author.

CAMPHOR—ITS POSSIBLE SOURCES AND PRODUCTION IN INDIA

BY P. N. DEOGUN
(*Deputy Conservator of Forests*)

SUMMARY

A short history of camphor, its demand and supply, its need by India and non-availability of any Indian raw material for its production is given. Experimental cultivation of a quick-growing and early camphor-yielding plant (*Ocimum kilimandscharicum*, Guerke.) at the Forest Research Institute, Dehra Dun, is described. Climatic and edaphic requirements of the new plant, methods of propagation and extraction of camphor are briefly described.

HISTORY

Most of us are familiar with camphor but only a few know its history and value. The first camphor known to man before the Christian Era was scraped from a tree, *Dryobalanops aromatica*, Gærtn. f. (family Dipterocarpaceæ), a native of Malaya. It was collected by felling the tree, splitting the trunk, and scraping off the camphor which occurs in the cavities or fissures, in irregular perpendicular veins, in and near the centre of the tree as a whitish deposit. This is called Borneo, Malaya, or Barus camphor, *apakwa* or *Bhimsaini kapur* of *vaids*, *Kafur-i-kasuri* or *Alfansuri* of *hakims*, and is greatly valued in the orient for religious ceremonies and for medicine. Dryobalanops camphor is the most expensive of all the camphors and even to-day has a demand in India. In recent years sometimes its price has been as high as 200 times the price of common camphor. Another source of camphor was discovered by the Chinese who obtained it by distilling the leaves and tops of *Blumea balsamifera* DC. (Family Compositæ). Camphor from this source is called *Ngai* or blumea camphor. This has been used as a substitute, or an adulterant, of the more expensive Borneo camphor.

It was in the ninth century or perhaps earlier that the Chinese distilled another camphor from the leaves and wood of *Cinnamomum camphora*, Nees and Eberm. (Family Lauraceæ) native of China, Formosa, etc. This is the common natural camphor of trade known as Formosa, China, Japan or laurus camphor.

Camphor in chemistry is a general term applied to a variety of oxygenized odoriferous and volatile solid substances all of vegetable origin and similar in their characters. Borneo, Ngai, Formosa and synthetic camphors are the trade names and although they have some differences are all commonly known as camphors. The first two are really borneols ($C_{10}H_{18}O$) and the last two camphors ($C_{10}H_{16}O$). The two borneols like the two camphors, though chemically the same, differ in their optical properties. Borneo camphor is dextrorotatory and Ngai lævorotatory ; Formosa camphor is dextrorotatory and synthetic camphor is optically inactive.

Camphor production by the end of the sixteenth or beginning of the seventeenth century passed into the hands of the Japanese. After the Sino-Japanese war and the occupation of Formosa by the latter, at the end of the 19th century, production of camphor was made a state monopoly by Japan. By this time camphor had assumed great prominence as a raw material in several chemical industries, the most important being the manufacture of celluloid including photographic films, medicine, smokeless gunpowder, etc. The Japanese took advantage of this and increased the price from about 150 sh. in 1901 to 400 sh. per cwt. in 1906, there being no other source then to meet the heavy demand of camphor by several industries based on it. Production of Borneo camphor was 3,000 to 4,000 lb. and of Ngai about 10,000 to 15,000 lb. per annum ; and these were hardly sufficient to meet the special type of demand in the orient, besides being more expensive. These supplies could hardly be increased and have remained practically the same even to-day. Under the circumstances it was but natural that Japan should have dictated her own terms. Such conditions were most propitious for discovering alternate sources and within four

years of the monopoly synthetic camphor was placed on the market.

The raw material for synthetic camphor is α — pinene, a constituent of many turpentines. Before the second world war more than two-fifths of the world's production of camphor was being produced synthetically.

DEMAND AND SUPPLY

It is not possible to estimate the world's demand of camphor. The rise in costs indicates that there is a good demand and nearly all that is produced is consumed. Figures of production by different countries are not available. In 1938, Japan, the main supplier of natural camphor, produced about 1,41,00,000 lb. of natural camphor, Germany about 87,00,000 lb. and U.S.A. more than 15,00,000 lb. of synthetic camphor. Other countries like France, U.S.S.R., China, etc., were also producing some. The total world's production may be safely put up at 2,50,00,000 lb. before the second world war.

India has always been a consumer and never a producer of camphor, ignoring the small quantities produced from imported turpentine oil. Nearly three generations ago (vide Report of the Lucknow Horticultural Gardens, 1882–83) a promise was made not only to make her self-sufficient but an exporter of about 6,00,000 lb. The position, however, remains unaltered. She has been importing on an average 18,90,400 lb. of camphor per year—average of the quinquennium 1935-40; during 1947-48 and 1948-49 she imported 16,74,904 and 12,38,613 lb. respectively; all this for medicinal and religious purposes only. An industrialized India's demand of camphor would be many times more than this quantity.

India has practically no raw material for the production of camphor. Her efforts to grow *Cinnamomum camphora* Nees and Eberm. and to extract camphor therefrom have resulted in failure. The trees grew but the yield of camphor was poor for commercial exploitation. Manufacture of synthetic camphor too has not been a possibility since the main supply of Indian turpentine oil is from chir pine (*Pinus longifolia*, Roxb.) which oil is poor in its content of α — pinene.

Kail pine (*Pinus excelsa*, Wall.) turpentine oil is rich in α — pinene, but then the collection of *kail* resin is expensive since very much smaller quantities can be collected per tree per year, due to the lower temperature of the localities where the tree grows and the consequent poor flow of resin and a short tapping season.

OCIMUM AS A SOURCE OF CAMPHOR

Efforts were continued to find out another source of natural camphor. There are dozens of plants which have camphor and/or borneol in them. All cannot be taken up for the commercial production of camphor or borneol as successful exploitation depends on the percentage of camphor or borneol in the plant, availability of raw material, etc. A species of *Ocimum*, viz., *O. kilimandscharicum*, Guerke. (Family Labiatæ), a native of Kenya (East Africa) was found to contain a commercially workable percentage of camphor and easy to propagate. Experiments were conducted on its cultivation and extraction of camphor in several countries including India. Work so far done by the Chemistry and Minor Forest Products Branch, Forest Research Institute, Dehra Dun, shows that this Ocimum could be easily propagated in India for the manufacture of camphor. This short note is intended to create interest among the readers and to help those who are interested and who have the facilities, in its cultivation, etc.

Ocimum kilimandscharicum, Guerke is a cousin of the sacred *Tulsi* (*O. sanctum*, Linn.) and can be grown without much technical skill. It can be coppiced a number of times each year, for a number of years, so that once introduced it can last for some years and save the cost of yearly planting. Coppiced plants get bushy and give better yields of leaf. The plant is ready for harvesting within 4 to 5 months of sowing the seed. The most interesting and useful feature of the plant is that it is not grazed or browsed by cattle (including sheep and goats) so that no protection against domestic and wild animals is required. Unlike many aromatic plants leaves of this Ocimum do not lose camphor even when stored for a year or so. This is a point in its favour so that the leaves collected from various cuttings can be stored and their distillation undertaken when the circumstances and season permit. The leaf may dry or rot, but the yield of camphor remains unaltered. Even the frosted

and rotted leaf, scraped from the ground, yields camphor. Recovery of camphor is also simple.

CLIMATIC AND EDAPHIC REQUIREMENTS OF THE NEW PLANT

Temperature.—High atmospheric temperatures do not appear to affect the plant provided the soil moisture is sufficient. Low temperatures, near about 34° F., will kill it back, but, with the advent of spring, the plant throws out new shoots again. Still lower temperatures, possibly below 30° F., will kill it outright, so that in such localities it takes the form of an annual.

Rainfall.—Experience has shown that this plant does well in areas where the rainfall is about 50 inches per annum, provided the soil is suitable. It can do with even a lesser rainfall, provided the rain is evenly distributed, or where the water table is high.

Altitude.—It grows best in plains but if other conditions are favourable the plant can grow even up to altitudes of 3,000 ft.

Soil.—The plant does not appear to be fastidious about soil requirements since it is known to come up on several types and has been observed to grow even on lime-mortar joints of floors, so that given requisite conditions of moisture and temperature it will grow even on very poor soils ; but to grow well and to produce a high yield of leaf per acre per year, it appears to prefer clayey soils. Generally speaking, heavy soils with impeded drainage, such as that found in the *Tarai*, in the U.P., are best suited for its cultivation.

Propagation.—When the species is to be introduced for the first time the best method is to raise plants in a nursery and transplant. Once a crop has been raised, further extensions in the planting area can be done either through planting of entire plants, or branch-cuttings (6″ long and about pencil thickness) or rooted branch-cuttings.

Under favourable conditions the plant reproduces through self-sown seed near about the mother plants. Natural seedlings can be utilized as transplants.

Direct sowings are not recommended for a variety of reasons.

NURSERY WORK

Seed is light (2,200 to a gram) and the germination per cent high. One ounce of seed sown over 10 beds ($10' \times 2'$) can supply enough plants for planting one acre ($2' \times 2'$) or more.

Nursery beds should be made with trenches all round, so that when the latter are filled with water, moisture rises to the bed surface through percolation.

Seed-beds should have fine pulverized light soil for at least two inches to three inches depth.

Seed should be sown when the atmospheric temperature is sufficiently high, generally after the middle of March, and the daily range of temperature not wide. Seed should be mixed with *ten to twenty* parts of sand for economy and uniform distribution. It should be sown either in lines, one inch apart or broadcast and *lightly* covered with light soil or fully rotted farm-yard manure. Sowings should be done when the soil is moist, not wet or dry. After sowing the beds should be covered with dry grass or leaves.

Watering should be regulated and timed to keep the surface soil moist. In no case should the beds be flooded or allowed to dry. When the seed starts germinating the grass or leaf-cover should be removed, and higher shades provided against sun and rain. When the seed has germinated watering should be discontinued for some time and then given at longer intervals as and when required.

In case trenches are not made for irrigation and the seed has been sown on flat beds, watering should be done with a fine spray and properly regulated and timed.

Germination starts in about 5 to 10 days and is complete in about 15 to 20 days.

If plants come up thickly the surplus ones should be pulled out leaving the best about $2'' \times 1''$ apart. Those pulled out can be planted in other beds and later on utilized for field planting.

PLANTING OF NURSERY STOCK

Area to be planted should be cleaned of all weeds. Seedlings are ready for transplanting when five to seven weeks old. Transplanting, however, should be done at the break of mon-

soon or earlier if irrigation is available. Plants should be dug up from the nursery beds and carried in baskets to the planting area, properly covered. These can be planted with naked roots provided the same are not unnecessarily exposed to the sun.

The simplest way of planting is to make a slit in the ground by pressing a spade, planting axe, notching spade, or ordinary *khurpa* or *ramba*. The slit should be sufficiently deep and wide to take in all the roots without curling them. After the roots have been placed in the slit it should be closed by pressing the planting tool in the soil a few inches away from the slit and levering it towards the plant. In no case should a plant be left loose in the ground.

MANURING

Manuring helps to produce a higher yield of leaf per acre. Farm-yard manure, compost, ammonium sulphate or their mixtures are recommended. Organic manure may be added before planting and chemical manures three to four weeks before the full blooming period of the plants.

HARVESTING

Season.—No hard and fast rules can be laid down as to the time and number of cuttings per year as these will depend upon the locality factors and growth of plants. When drawing up a harvesting time-table the following points should be borne in mind :—

(*a*) Production of camphor and oil per acre, which is the main object, depends on the production of leaf and to some extent on the time of cutting.

(*b*) Each extra cutting means extra cost and weakening of the plant at a certain stage.

Unless these extra cuttings yield significantly higher yields of leaf per acre, per year, to offset the extra cost, etc., they need not be done.

If planting in the field were done in April–May one cutting at the beginning of rains and another at the end of the growing season in the first year should be done, irrespective of the places. In the second and subsequent years one or more cuttings may be required. It is best to carry out local experiments to find out the total yield of leaf per acre, per year, with one or more cuttings and to draw up a suitable programme. In the meantime cutting may be done twice or thrice a year at a time when the plants have grown to about 2 ft. in height and when the lower leaves begin to yellow off. A provisional time-table can be :—1. March–April. 2. August–September. 3. November–December.

In cold localities where the plant is to be grown as an annual only two cuttings will be possible, one after two to three months of planting and the other at the end of the growing season or before the frost. The object of the first cutting is to help the formation of a bush and production of more leaf in the final cutting.

Method.—Cutting can be done with ordinary sickles or right-angled knives. Plants should be cut 2″ to 3″ above the ground provided there is no danger of flooding of the area in which case they might be cut even a little higher.

Cut plants should be placed across the rows as cutting proceeds and collected in heaps at the end of the day, in places where thrashing is to be done.

COLLECTION AND STORAGE OF LEAF

When the plants have dried, or somewhat rotted in heaps, they should be thrashed either with sticks or as is done in case of wheat and other field crops. Leaf can be bagged or heaped under sheds, and stems utilized for raising steam required for the distillation.

EXTRACTION OF CAMPHOR AND CAMPHOR OIL

The Chinese and Formosans employ or employed simple methods for the extraction of camphor from Blumea and Cinnamomum plants.

On the fire-hole is placed an earthen or metal vessel filled with water and covered with a perforated lid. On this is fixed a cylindrical tube or barrel made of wood or woven bamboo, open at both ends. This is packed with the material to be distilled. On top of the tube or barrel is placed an inverted jar. This jar is water-cooled. Joints between the tube or barrel and other vessels are made air tight by placing wet hemp in-between or by luting them

with clay. The tube or barrel is plastered with mud so that there is no leakage of steam.

When fire is lit under the vessel containing water, steam is produced. This steam while rising through the material in the tube or barrel carries camphor and oil from the leaves, and on cooling against the top jar, deposits camphor. Camphor is scraped and collected.

A number of such stills are worked at a time. Sometimes these are built in an oblong mud-brick structure 10′ × 6′ × 4′ with fire-holes. The water vessel and the tube or barrel remain inside the brick structure but the condensing jar remains outside. This helps in conserving heat and takes lesser fuel and time for distillation.

Under the above method oil is not recovered.

The Japanese improved the above method by directing the camphor and oil-laden steam from the still, leading it to a series of bottomless wooden chambers, placed in a shallow open wooden-box with running water and condensing it in the system. These chambers are also kept cooled from above. Camphor and oil get deposited on the surface of the water inside these chambers. Some oil is lost as a small percentage of it gets dissolved in water. The condensing system, however, leaves room for improvements.

On a small scale, camphor can be collected by boiling the Ocimum leaf in a *degchi* with an inverted *degchi* on top, on an ordinary *choola*. The joint between the two *degchis* should be luted with kneaded *ata* or clay. As soon as boiling has started, fire should be damped; otherwise the steam will force its escape. The top *degchi* must be cooled by placing a wet cloth on it and changing the same frequently. Camphor will get deposited on the inside of the top *degchi* and can be scraped after a few charges.

A couple of hours distillation is sufficient to extract the camphor and oil.

COMMERCIAL POSSIBILITIES

As a commercial proposition the main points to concentrate attention on are :—(1) Yield of leaf per acre per annum, (2) Cost of production of leaf, (3) Yield of camphor and oil from leaf, (4) Cost of production of camphor and oil, (5) Sale rates of camphor and oil.

Generally speaking the yield of oil and camphor from the dry leaf varies between 4 to 5·5% of which the camphor content is 60 to 70 per cent (zero moisture basis).

Yield of leaf per acre in Dehra Dun has been up to 2,000 lb., air dry (1,700 lb. at zero moisture), per year, but Dehra Dun does not offer the requisite type of soil. Although actual figures of yield of leaf from *Tarai* are not available, observations show that far better yields are possible in *Tarai* type soil.

If more than 3,000 lb. of leaf (on zero moisture basis) per acre could be produced there is no reason why the production of camphor should not be a commercial success. Actually it may be possible to produce much more.

The cost of production of leaf in suitable localities should not be high as after its introduction the plant does not need much looking after, not even irrigation in areas with heavy soils, impeded drainage, and sufficient rainfall. The Cost of production of camphor and oil should not be high since the leaves can be distilled at a low steam pressure and do not take long for complete distillation. Readers who have the facilities are requested to raise Ocimum crops on measured areas and work out the leaf yields per acre.

As stated above the idea of this article is to create interest among the readers in the new plant, which appears to have a future for the production of camphor in India. Should any one of them wish to go further in the detailed working of either the cultivation and/or distillation he is welcome to write to the Chemistry and Minor Forests Products Branch, Forest Research Institute, New Forest, Dehra Dun.

The author has had the fullest and ungrudging co-operation of the entire Chemistry and Minor Forest Products Branch, particularly of Messrs. R. L. Badhwar, B. S. Varma, A. C. Dey and G. V. Karira to whom he is very thankful.

THE DISTRIBUTION OF CONIFERS IN THE KULU HIMALAYAS WITH SPECIAL RELATION TO GEOLOGY

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In hill areas of the Kulu forest division, as also in other parts of the Western Himalayas, the distribution of conifer forests has been broadly related by most foresters, notably, Troup (1921), Parker (1918) and Champion (1938) to climatic factors, chiefly rainfall and temperature.

In the Western Himalayas changes in climate (rainfall, temperature, humidity, etc.) closely follow altitude and on account of the general SE.–NW. alignment of the major ranges variations produced by latitude generally coincide with the effects of altitude. Hence, in the outer ranges there is a general increase in summer rainfall and a decrease in temperature from south to north and from low to high altitudes. The northern slopes in these hills, for this reason, are comparatively cooler than southern slopes and similar climatic differences exist between western and eastern slopes as well.

This general relationship between climate and altitude, however, is modified in the inner Himalayas, which receive less rainfall during summer and have higher precipitation during winter months. The inner valleys are comparatively drier in summer and show a gradual decrease in summer rainfall from outer to inner ranges. In winter, they receive more snow than outer ranges, and it stays there for a longer period. The general configuration of valleys with respect to the direction of south-westerly monsoons further alters this general relationship between climate and altitude; and rainfall, temperature, etc., are generally different in side valleys from those in valleys of the main rivers.

On account of this general relationship between climate and altitude the main conifer forests in this region have been broadly related to altitudinal zones. Thus, *Pinus longifolia* generally occupies the lowest elevational zone in the Himalayas and silver fir (*Abies pindrow*) generally reaches upper limits of tree growth. *Pinus excelsa*, *Cedrus deodara* and *Picea smithiana* occur at intermediate altitudes but not in a very regular order. From the altitudinal distribution of species given in Fig. 1, it is obvious that there is a considerable overlapping in the altitudinal zones of different species; and towards the extreme limits of their distribution they form mixed conifer forests.

The distribution, growth and reproduction of different conifer communities in such mixed forests in a zone of identical climate and altitude is of special interest and the present study was mainly concerned with finding out factors, other than those of climate, which govern the distribution of each community over small areas in this region.

Early workers have explained by climatic theory even small variations in forest cover in adjacent areas or on two sides of a valley by stressing on small variations that exist in atmospheric temperature, humidity, rainfall, etc. Thus, Troup (1921, p. XXXVI) states that "in hill regions variations in the forest formation are observable with changes of aspect and configuration; where the underlying rock does not change; the more xerophilous species occupy the hotter aspect and the drier ridges while the more hygrophilous species occupy the cooler aspect and moisture depressions".

In the Parbatti valley of the Kulu Himalayas both xerophilous and hygrophilous communities are encountered on the same aspect and at some places the chir pine community, which usually affects southern aspects was found on northern aspects. At higher elevations where the blue pine occured with spruce and silver fir it occupied southern aspects, though at lower levels with chir pine it was found on northern aspects. Spruce and silver fir were found on all aspects above 9,000 ft. in the valley. This seems to suggest that there is another factor more potent than aspect which determines the distribution of these communities.

Edaphic factors were next considered. Taylor, Mahendru, Mehta and Hoon (1935) have shown that forest types in the Kulu Himalayas are very broadly related to the degree of

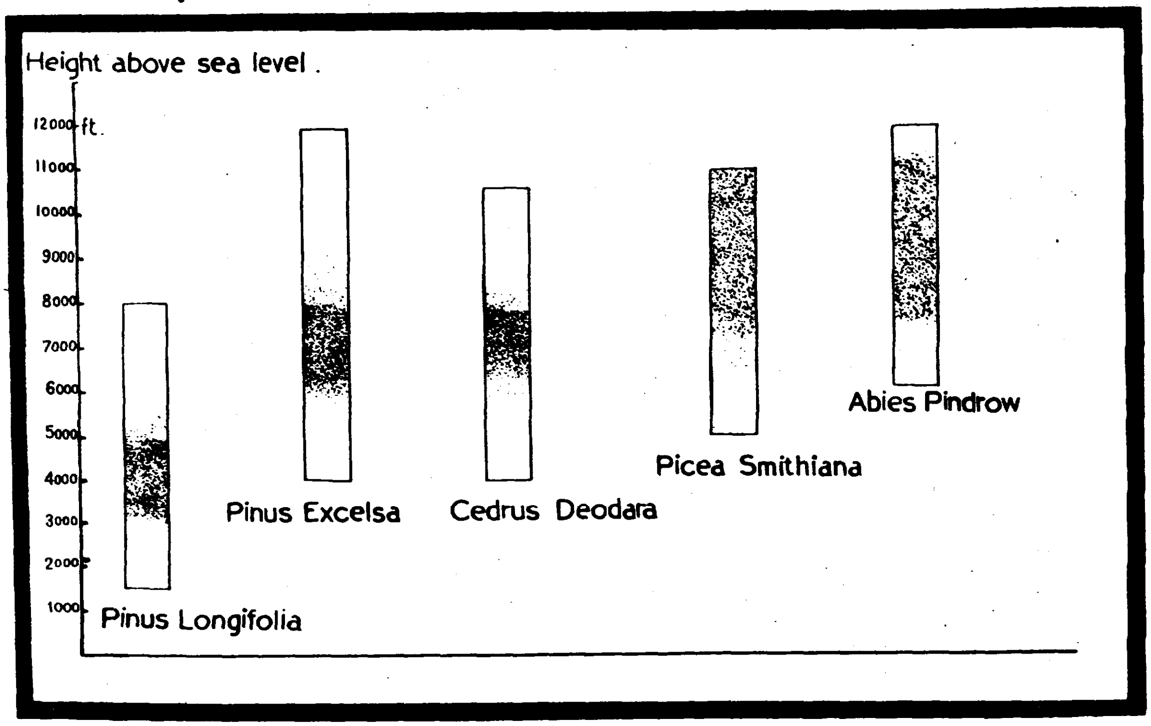


FIG. 1.—A Diagramatic representation of altitudinal distribution of various conifer species in the Western Himalaya. Darker area in the figure indicates altitudes where the species occurs predominantly.

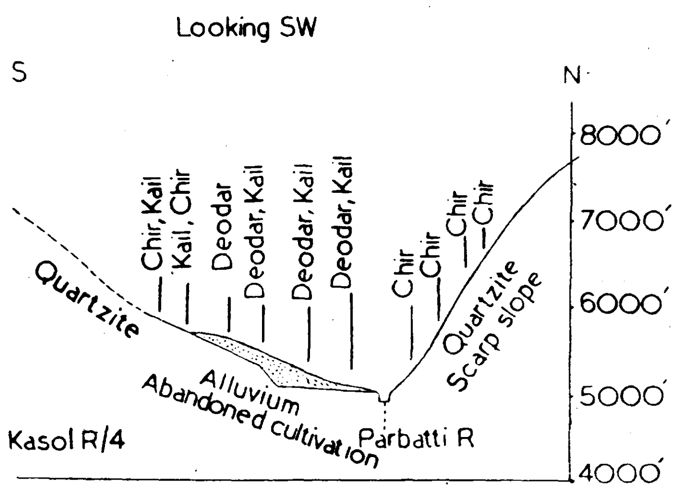


FIG. 2.—Relation between tree vegetation and main geological features near Kasol Parbatti Valley.

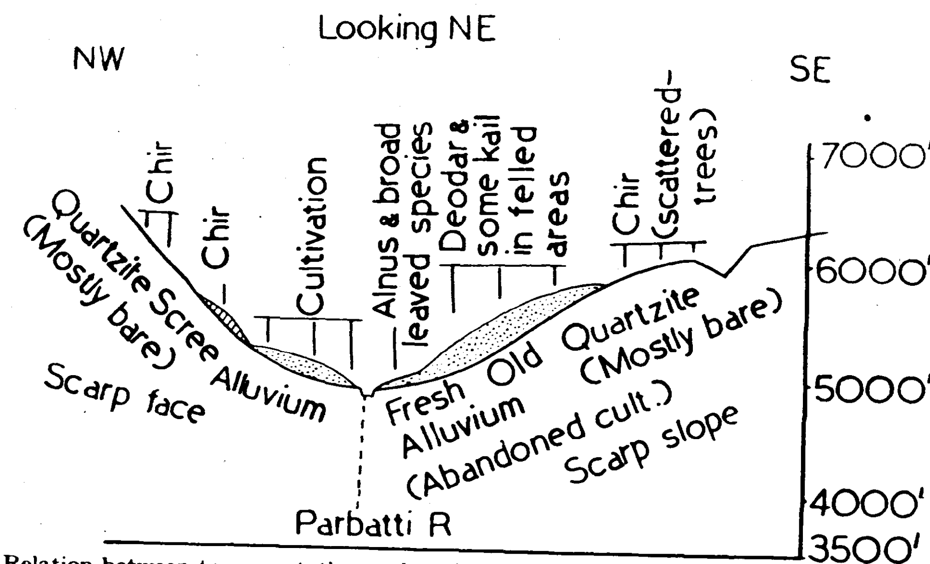
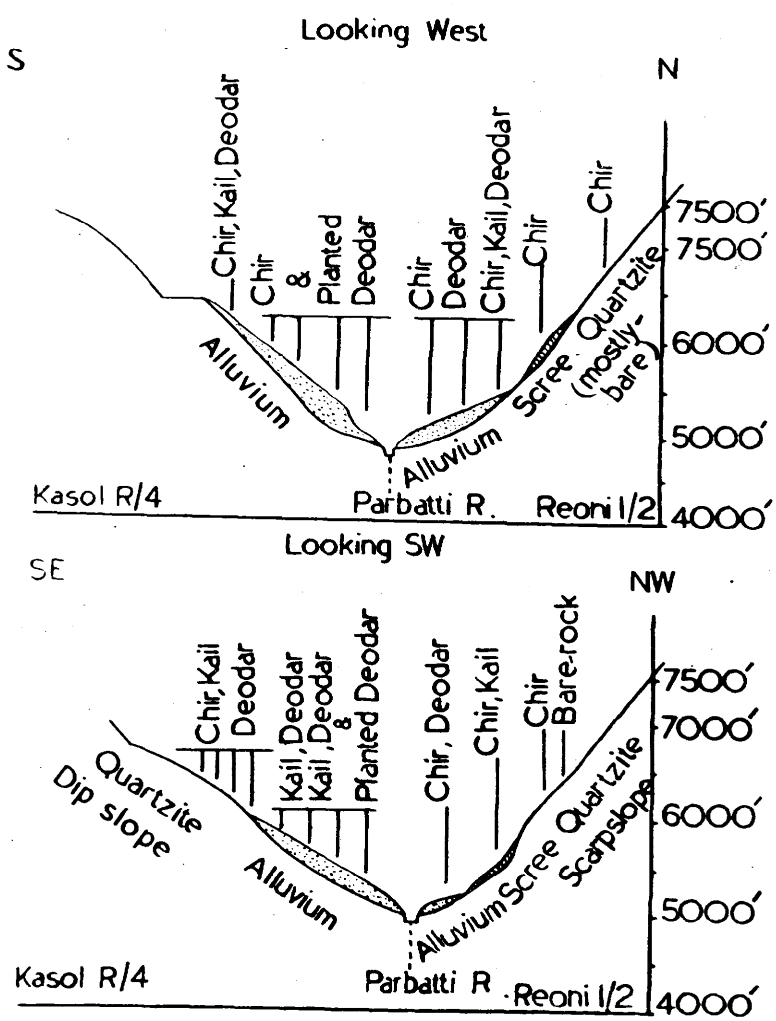


FIG. 3.—Relation between tree vegetation and surface geology near Kasol Rest House, Parbatti Valley.



FIGS. 4, 5.—Relation between tree vegetation and geology in the Parbatti Valley.
4—Section a little below Village Chhalal.
5—Section above half a mile from Village Chhalal.

maturity of the soil. Thus, the chir pine community occured on skeletal or immature soils, while the blue pine and deodar were found on the best developed podsolic profiles in the area under uniform climatic conditions. These conclusions are in general agreement with our idea of succession of forest communities in the area, but these authors have not considered the basic fact of the origin of the soils.

The development and maturity of soils depend upon *climate and geological formation*. In a zone of identical climate, the only other factor which deserved a careful study was the geology and attention was, therefore, specially paid to examine the main geological features of the area in relation to forest types. This study seemed desirable since the composition and structure of the underlying rock exercises a powerful effect on the growth of vegetation on the surface.

The importance of geology in the study of forest vegetation in India was recognized as early as 1921 by Troup who recorded that "the effect of geological formation in determining the local distribution of the blue pine and chir pine towards the lower limit of the former is well illustrated below Bandal in the Tirthan valley, Kulu. Normally the blue pine occurs above the chir on quartzite, on which owing to the dryness of the soil the blue pine again makes its appearance on mica schist" (Troup, *loc. cit.*, p. 1018, see p. 1045 also).

Although the importance of geology in determining surface vegetation was recognized early, later workers (see Champion, 1938) have not used this in classifying forest types of India and as Champion's preliminary classification has to be made ecologically sound, it is necessary to critically examine and enlarge his basic concept. Champion's work as he himself admits was a compilation of known knowledge from working plans which are by no means prepared on ecological studies. My endeavour in these studies is to relate forest types to fundamental factors of soil and geology, and therefore, special emphasis is laid on these ecological factors. This approach has obvious advantages since disturbance of soils and ecological features to produce desirable plant communities is within the power of human effort, whereas atmospheric factors cannot be changed. It is therefore, necessary that sufficient knowledge be collected of those ecological factors which could be controlled by reasonable means.

The effect of rock on surface vegetation is two-fold (Puri, 1949 b, 1949 c):—(1) lithological and (2) structural. The first factor has long been appreciated and it is now well known that the growth of vegetation at the surface is governed by presence or absence of mineral elements in the rock.

The second factor is presented for the first time and relates to the availability of mineral salts and water supply in a single bed in accordance with position on dip and scarp respectively. In a single bed dip slope is a flushed area towards which mineral rich water seeps through the strata of the rock from adjoining areas (Puri, *loc. cit.*). The scarp slope, on the other hand is leached of mineral salts, which seep away to other areas in the direction of the dip of the strata of the rock. Therefore, soils on dip slope are expected to be different in moisture content, base saturation, pH, etc., from those on scarp slope (see Puri, 1949 a and 1949 d).

In the Western Himalayas the strata of the rock dip in various directions, usually towards N., NNE., or NNW., and in some cases the effect of this factor on vegetation coincides with favourable effects of aspect. An interesting example of this is seen in the Simla hills. While describing the relation between aspect and vegetation Champion (1938) observes "It is a general characteristic of the Western Himalayas that southern slopes are bare of forest while northern slopes are covered with forest. Hence looking north from Simla the hills appear to have no forest, whereas looking south from the inner ranges the whole country appears covered with forest". West's (1939) observation on geological features of the area made at about the same time shows that northern slope of the hills at Simla is an escarpment of limestone. He states: "The Shali peak forms a prominent feature in the middle distance in the view North-east of Simla. To anyone familiar only with this view of the mountain, bare dip slope of massive limestone, it would probably come as a surprise to learn that the northern slopes are thickly covered with a dense forest of deodar, oak, and pine". The dense forest on the scarp is undoubtedly due to the presence of lime on the surface to which the favourable effect of climate has also contributed.

Such examples showing coincidence between aspect and slope are by no means rare in the Himalayas. To give another illustration, looking north-east into the Parbatti valley from the top of Bijli Mahdeo one sees a panoramic view of bare scarp slopes of quartzite and thickly covered dip slopes bearing luxuriant crops of kail and deodar. In this case northern aspect coincides with dip slope and southern with scarp and mask the effect on vegetation of the underlying rock. Smythies (1919) also called attention to instances of aspect masking the effects of underlying rock on vegetation in the Himalayas.

The study of forest communities in relation to geological feature and soil development is of fundamental importance to silviculture, since silvicultural operations designed to produce better growth and reproduction (both natural and artificial) of forest communities are based on disturbing the usual trend of biological activities in surface soils. It is now well-known that (Romell, *loc. cit.*, see Puri, 1948) opening of canopy or cutting of trees, ground flora or shrub for effecting regeneration alters the physiological and ecological balance in a community, creating suitable locality factors for forest reproduction.

For the simple and natural solution of regeneration problems in the Kulu forests, therefore, it is essential that extensive and intensive studies be made (1) in finding out the fundamental relationship between plant communities and locality factors in diverse conditions of climate and soil and (2) in applying the fundamental knowledge thus collected in successful forestry, keeping in view the maximum yield and preservation of the soil. In the present paper a beginning has been made to provide information on the first point ; and in the light of this some remarks will be offered on the second point as well.

Plant Communities in Relation to Geology

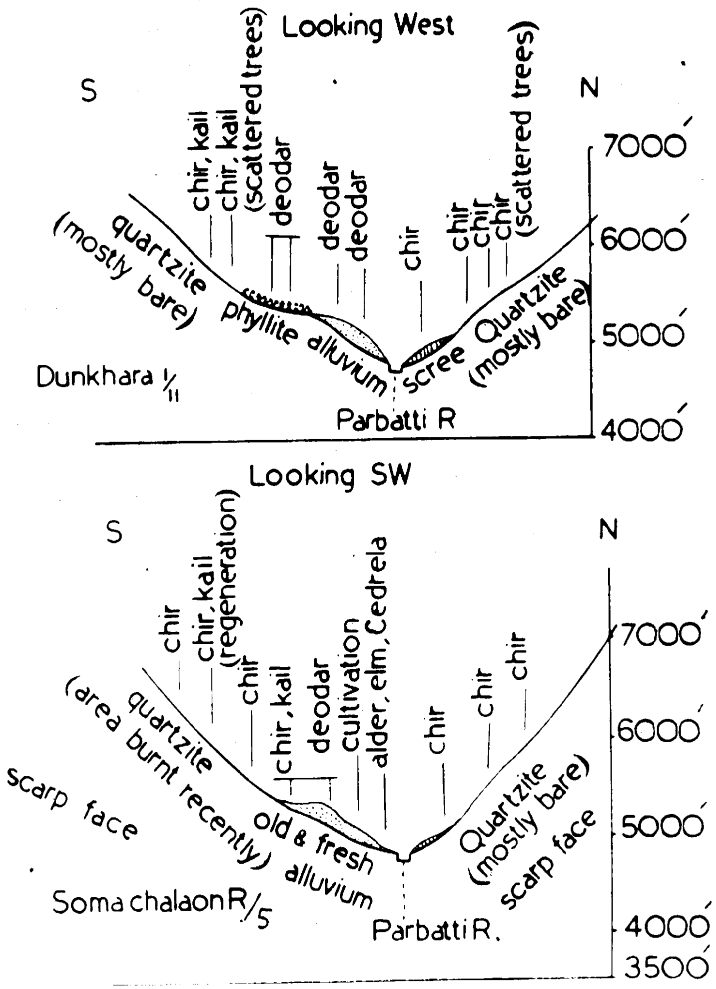
The area covered by this investigation extends from Jari to Manikaran, and includes the Pulga and Kheirganga forests in the Parbatti valley ; Kulu, Manali and Naggar forests in the Beas valley and lower parts of Sarwari valley near Sultanpur. Detailed studies, however, are presented only for the Parbatti valley forests.

The Parbatti valley is a narrow, V-shaped valley carved by the river Parbatti into the substrata of quartzite in its lower reaches and of mica- and biotite-schist and shales at higher levels. The direction of the valley is SE.–NW. between Kheirganga and Manikaran and NE.–SW. between Kasol and Jari.

The Parbatti river is still young and actively cuts its way into the rock forming deep gorges in quartzite country. From the impressive thickness of flood-plain deposits, which may vary between 100–700 ft. in the valley, it appears that this river must have been much stronger in the past than it is now. The alluvial deposits are variable in composition from sands to clays, and provide in the area some of the best agricultural lands of high fertility. Some of the best forests of deodar and kail are also found on these deposits. Freshly laid deposits bear stately groves of *Alnus nitida*, mostly pure, or, sometimes accompanied by *Cedrela serrata*, *Rhus*, *Aesculus indica*, elm, poplar or oak (*Quercus dilatata*), however, in some places pines and deodar are among the first colonists and on account of the sandy nature of the soil alders and other broad-leaved species are not present here.

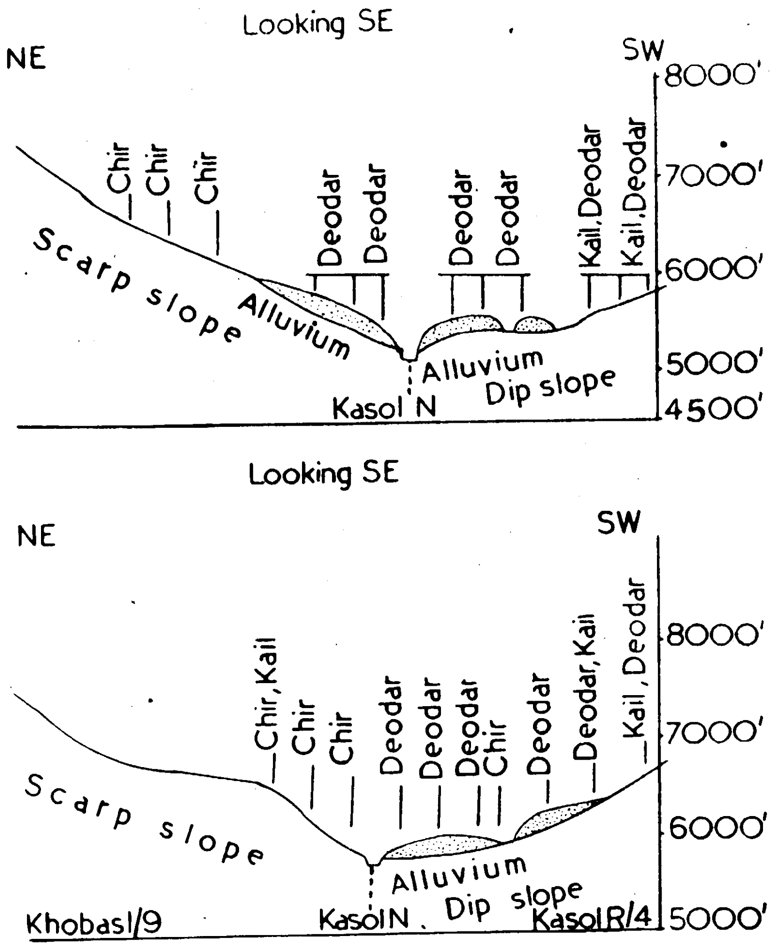
The dominant rock between Jari and Manikaran is quartzite, interbedded locally with thick bands of mica schists, phyllites, sandstones and shales. The strata of the rock dip generally towards NNE. South-western sides in all side valleys are, therefore, scarp slopes, while dip slopes are on the north-eastern sides. Both sides in the Parbatti valley between Jari and Manikaran are scarp faces.

Topographically, scarp slopes in this area are steep and precipitous and soil seldom collects in appreciable quantity along them. At lower levels cones of scree, chiefly consisting of large blocks, occur, and these too are mostly unstable. Fine scree cones may also occur rarely where quartzite rock is finally weathered into sand. Dip slopes are invariably gentle and are topographically stable. On account of seepage waters the rock gets more weathered on the surface forming deep soils, which attain maturity under vegetation cover. Thus, topographically both sides in the valley between Jari and Manikaran being scarp faces are equally unstable except where surface deposits are overlying the solid rock. The surface



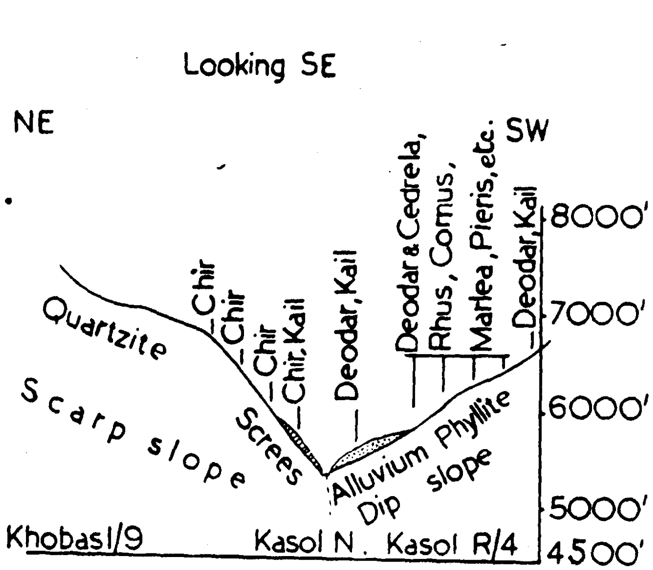
FIGS. 6, 7.—Relation between tree vegetation and geology in the Parbatti Valley.

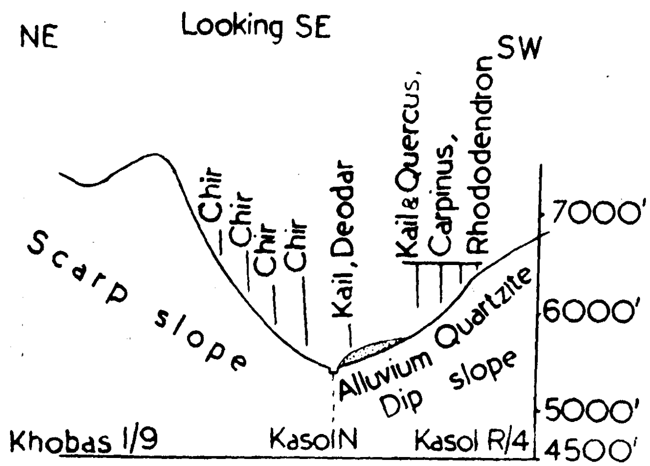
6—Section near Dunkhara Village.
7—Section near Surn Ropa Village.



FIGS. 8, 9.—Relation between tree vegetation and structural geology in the Kasol Valley.

8—Section near Kasol where the Nala meets with Parbatti River.
9—Section about 3½ furlongs in the Valley.





.FIGS. 10, 11.—Relation between tree vegetation and structural geology in the Kasol Valley.

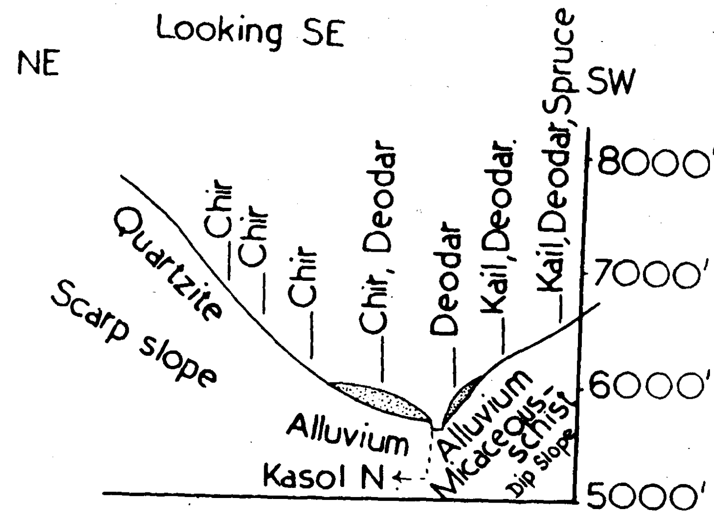


FIG. 12.—Relation between Forest communities and geological features in the Kasol Valley, near nursery.

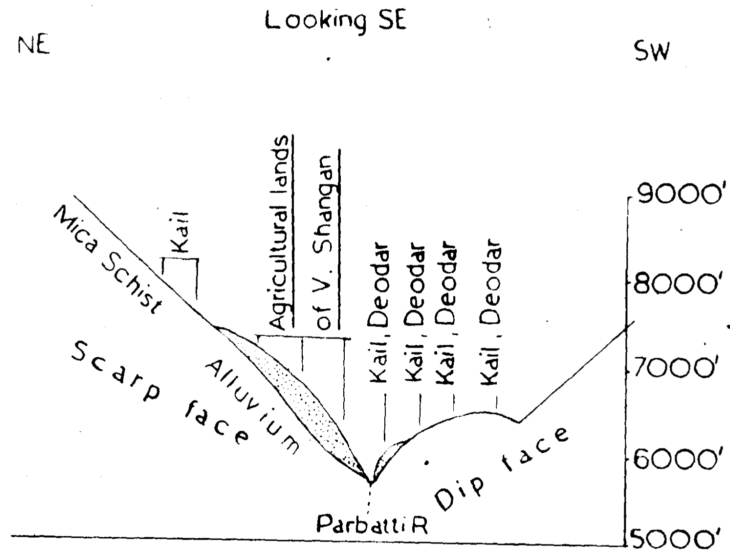


FIG. 13.—Relation between tree communities and main geological features in the Parbatti Valley above the Village of Shangan.

deposits whether they are alluvial or glacial in origin are gently sloping and gravitationally unstable. They are composed of reassorted heterogenous materials and weather easily to produce an undulating, gently sloping topography.

Quartzite rock is poor in calcium salts, hence soils on scarp slope are usually base deficient and dry, while those on dip slope are less base deficient and moister. This is evidenced as shown below, by scarp slopes of this rock being often bare or supporting only stunted and scattered trees of the chir pine, while dip slopes having usually good forests of kail, or chir–kail community in developmental stages.

Mica schists and chlorite schists contain between 0·5 to 10 per cent of CaO* and the amount of Calcium oxide in phyllites and shales is still greater. Thus the soils produced from these two types of rock have more calcium than those formed from quartzite. Both on scarp and dip slopes of these rocks, therefore, soils have ample amounts of calcium for forest growth, though on dip slopes these would be richer in bases. These two rocks, as will be shown below, generally bear a luxuriant growth of the blue pine and deodar; and several broad-leaved species usually occur on dip slopes of phyllite or schist.

In this area, under the existing conditions of climate with high temperature and monsoonic rainfall, phyllites, shales and sandstones especially along dip slope weather more easily than quartzites or schists, forming series of depressions with finely weathered, deep moist soils, and spurs with thin, skeletal and dry soils. Physiologically, therefore, soils on spurs, correspond to those on scarps, and soils in depressions have much the same properties as those occuring on dip slopes. Thus, scarp type forest may extend to dip slopes on spurs and in rare cases dip type may also be found in depressions on the scarp slope. There may also occur "physiological dip" and "physiological scarp" in the main valley; and vegetation types in these places will be different from main types on the respective slopes.

In addition to soils formed in situ from various rocks there occur in the valley extensive flood-plain deposits, screes and glacial moraines, the physical and chemical composition of which may vary according to the composition of rocks from which they were derived, and the time of their deposition. Most of the older flood-plain deposits are predominantly composed of clays and silts, but in younger deposits sands are in higher proportions. The flood-plain deposits and screes occur at all elevations, however, moraines occur only at higher altitudes in side valleys. Moraines at Pulga are mainly composed of clays, which are deep and moist and contain small blocks of rock at great depth. In the main valley of the Parbatti river there is no evidence of glaciation though the occurrence of angular blocks with poorly rounded edges, at some places, in flood-plain deposits, reminds one of morainic deposits.

The chief trend in the development of soil under the existing conditions of temperature and rainfall is evaporation, especially at lower altitudes as is shown by the data of Taylor, Mahendru, Mehta and Hoon (1935). As a result of this normal podsol profiles with base deficient surface soils are nowhere found in this region. During most of the time in a year, due to evaporation mineral rich water from lower layers is brought up to the surface layers of the soil raising its pH and base status. For a short period during the monsoons, however, leaching becomes predominant and under its influence the normal development of the soil profile proceeds. The effect of leaching is greatly felt under close canopies of deodar, spruce or the blue pine on flood-plain deposits of a silty or sandy nature where, on account of low evaporation, podsolic types of profile with a bleached A–layer and humus rich B–layer develop. These podsol soils called by Taylor, Hoon and Mehta (1935) as Kulu coniferous soils of the podsol group are, however, fundamentally different from conifer podsols of higher latitudes in having a high pH and high base content of surface layers. These are in reality immature soils whose development is impeded mainly by tropical climatic conditions with a high evaporation from the soil surface for most of the time in a year and high calcium content of leaf litter of tree species.

Taylor and others (*loc. cit.*) have laid more emphasis on the high amount of foliar calcium in making surface layers of these soils more base saturated but a comparison of Kulu conditions with those found at higher latitudes where

* I am grateful to the Director, Geological Survey of India, Calcutta, for this information.

evaporation is generally low and rainfall uniformly distributed during the year will show that climatic factor is of greater importance than of vegetation in determining the base status of surface layers of the soil in both cases. That the effect of vegetation is subordinate to that of the climate in this case may be clear by comparing the foliar CaO in litter of some of the Kulu species with those that grow in higher latitudes in Europe. For example, European pine, *Pinus sylvestris* contains very low amounts of mineral matter (2·910%) out of which Calcium oxide is only 0·786% (Puri, 1948). In humid climate of northern Europe the soils under scotch pine, become very acidic on the surface and develop a true podsolic profile. The percentage of ash and Calcium in the Western Himalayan conifers and associated broadleaved species as given below will reveal that although in the Himalayan pines foliar Ca is less than in the European pine, the soils on the surface do not become so much base deficient.

TABLE I

Percentage of ash and CaO (on dry basis, average of two determinations) in leaves of the following species from the Parbatti valley, Kulu.

	Ash %	CaO %
1. *Pinus longifolia*	3·57	0·56
2. *Pinus excelsa*	3·78	0·98
3. *Quercus semecarpifolia*	4·05	1·57
4. *Abies webbiana*	4·70	1·59
5. *Quercus dilatata*	4·88	1·65
6. *Cedrus deodara*	5·25	1·80
7. *Quercus incana*	5·73	2·00
8. *Picea smithiana*	7·29	2·24
9. *Alnus nitida*	10·38	2·29
10. *Populus ciliata*	8·10	2·35
11. *Juglans regia*	13·45	2·42
12. *Aesculus indica*	10·42	3·34
13. *Prunus padus*	12·05	3·41
14. *Cornus macrophylla*	14·95	5·63

It will be seen that the two Himalayan pines record the lowest figures among Himalayan species and one of these has higher and the other lower figure of CaO than that of the European pine. Silver fir, deodar and Spruce have quite high ash, nearly equal to, or in the case of spruce even more than, European oak, beech and hornbeam (see Puri, 1948). The Western Himalayan oaks have almost the same amount of ash as the European oak but other species, viz., walnut, popular, cherry, *Cornus*, etc., in our forests have very high percentage of mineral matter as in European cherry, horse chestnut, poplar, ash, lime, etc. (see Puri, *loc. cit.*). The percentage of CaO nearly runs parallel to the percentage of ash except in a few cases, e.g., in *Cornus macrophylla* CaO is high and in *Juglans regia* it is somewhat lower than normal. It is interesting to see that although there is not much difference in foliar Ca of the Himalayan and European species, soils under the Himalayan pines remain base saturated as is shown by extensive works of Taylor and others (*loc. cit.*), while high acidic conditions and base deficiency develop under pines, oak and even beech in European forests. This is clearly ascribable to leaching under high precipitation/evaporation factor of the climate.

From the table it is clear that mineral requirements of the chir pine and blue pine are very small ; hence both these species flourish on quartzite rock. The chir pine community maintains itself on the scarp slope, but on the dip slope it is succeeded by the blue pine and depending upon the stage in succession the forests are either composed of pure kail or have variable mixtures of the chir pine and kail. Some of the best examples of this type are found in the Parbatti valley between Jari and Kasol and in the Kasol valley as shown in figs. 2–6 and 7–11.

Between Jari and Kasol, the river cuts against the direction of the dip of the strata, both sides of the Parbatti valley are, therefore, scarp faces, and bear chir pine community on exposed quartzite rock (photo 1). These chir pine forests tend to remain in a seral stage and on account of the skeletal nature of these soils they do not develop further. However, those on screes or alluvia (photo 2) show the following succession: Chir→Kail→Kail-Deodar. The blue pine and deodar are common on flood-plain deposits and are often found in colonizing stages with the chir pine (photo 3). Depending upon the calcium content of these deposits they show a succession from Chir→Kail→Kail-Deodar→Deodar. Both the blue pine and deodar forests on flood-plain deposits are close canopied and have a poor ground flora of scattered shrubs of *Berberis*, *Cotoneaster*, *Rubus*, and herbs like *Galium*, *Salvia*, *Fragaria*, *Viola* and grasses. The observations of Taylor

and others (*loc. cit.*) show that the soils under pure deodar or blue pine community usually show a podsolic profile, especially if they are bouldery and sandy, in which B–layer, rich in organic matter is well developed ; and on more sandy substratum A–layer is very much bleached. The surface layer may or may not have much peat but has always a high pH and is saturated with bases. My field observations on this point agree with these authors.

Mature crops of deodar on flood-plain deposits at most places show little regeneration but in felled areas seedlings of the blue pine and deodar are profuse and the vegetation in gaps naturally progresses to deodar forests.

Extensive stretches of river deposits in this valley where there were originally trees of the chir pine, or/and the blue pine have been successfully planted with deodar (Figs. 4 and 5) ; and this being a final community in this area the laying-out of these plantations has been fortunately on sound ecological lines. Soils under these plantations as well show podsolic profiles (see Taylor and others, *loc. cit.*).

In addition to flood-plain deposits deodar forests occur in this valley on soils derived from phyllite and shales (see also Fig. 10 in the Kasol valley). Ground flora under these forests is profuse and tree canopy has several broadleaved species, e.g., *Marlea begoniæfolia*, *Cedrela serrata*, *Rhus punjabensis*, *Pieris ovalifolia*, etc., these sometimes form close thickets with deodar. Such forests of deodar were seen to regenerate successfully.

On abandoned cultivation lands (Figs. 3 and 12) there occur extensive forests of deodar which when felled allow in the growth of early seral species like the blue pine and even chir pine.

Early colonists on freshly laid alluvia are either the broadleaved species of *Alnus nitida* (Figs. 3, 7) or the blue pine and deodar. These, however, seem to develop into pure or mixed deodar forests eventually, as is evidenced by the occurrence of such communities on old deposits.

To sum up, it seems that between Jari and Kasol, along both sides of the Parbatti valley, chir pine is the dominant tree species on scarp face of the quartzite, and these forests remain in seral or developmental conditions on account of the immature topography and low amount of calcium salts. Climatic conditions and effects of aspect also favour the same trend of development. On screes, flood-plain deposits, phyllite, shales and dip slope of quartzite, chir pine is the pioneer community and is succeeded by Kail→Kail-Deodar→Deodar. This succession in vegetation shows a corresponding change in the soil and in final communities of the blue pine or/and deodar there occur immature podsols as is shown by Taylor and others (*loc. cit.*). The natural regeneration of deodar in final stages of succession occurs where small gaps in the canopy are found ; in larger openings seedlings of kail and even chir pine occur in greater numbers than those of deodar. The deodar plantations in the area are ecologically sound and the natural succession in the chir and kail communities on clayey or silty flood-plain deposits, and on dip slopes of phyllite or sandstone could be profitably accelerated by artificially stocking these areas with deodar, without any loss to the soil. Large stretches of flood-plain deposits now neglected as Zamindari forests or under the plough could also be planted with kail and deodar to get good supplies of deodar timber, if necessary.

(*b*) *Kasol valley*.—With a view to confirm and extend the conclusions drawn from the study of forests in the Parbatti valley, the Kasol valley forests were next examined in relation to the geological factor.

Unlike the Parbatti valley, Kasol is a strike valley carved into the sub-strata of quartzite, phyllite and schistose rocks by Kasol or Grahan Nal. The flow of the Nal is SE.–NW., against the strike of the rock, the SW. side is therefore, dip slope and the NE. is an escarpment.

Figs. 8–12 give the vegetation of the valley in relation to main geological features starting from the junction of the Kasol Nal with the Parbatti river to about 2 miles inwards. It will be seen from these figures that :—

(1) On scarp slopes of quartzite, the chir pine forms seral or developmental forests (Figs. 8–12, photo 4).

(2) On dip slope of quartzite (Fig. 11) the chir pine is succeeded by the blue pine, which is associated with *Quercus incana*, *Carpinus viminea*, *Rhododendron arboreum*, etc. On micaceous schist (Fig. 12) the succession

proceeds further to Kail→Deodar at lower (photo 5) and Kail→Deodar→Spruce at higher elevations. Phyllites (Fig. 10) bear the final community of deodar with a luxuriant ground flora; with trees of *Cedrela serrata*, *Cornus macrophylla*, *Marlea begonæfolia*, *Pieris ovalifolia*, *Juglans regia*, etc., occurring in the upper storey (photo 6). An interesting example of quartzite formation overlain by Phyllites is seen above forest nursery in this valley. As seen in photo 7 dip slopes of phyllite bears deodar whereas kail and chir pine are seen on the scarp slope. On quartzite *Quercus incana* and kail occur on dip slope of quartzite, whereas on scarp slope there were scattered trees of chir pine.

(3) On flood-plain deposits the following succession is observed ; Chir pine→Kail-Deodar→Deodar (photo 8).

From the above brief sketch of the vegetation in the Kasol valley it is clear that both in this valley and in the Parbatti similar geological factors govern the distribution, reproduction and development of conifer communities.

(*c*) *Parbatti valley above Manikaran.*—Above Manikaran, the river flows in SE.–NW. direction and flood-plain deposits are present on NE. side of the river. The chief rock types here are micaceous schists and sandstones, the strata of which dip towards NE. The south-western side of the valley is, therefore, dip slope and NE. side is a scarp. Extensive flood-plain deposits on the NE. side have hidden the underlying solid rock so that the vegetation is generally governed by the surface deposits.

A detailed relationship between tree communities and main geological features is shown in Figs. 13–16. It will be seen that (1) both quartzite rock and chir pine are conspicuous by their absence (2) the blue pine forests mainly occur on scarp slope of schist (Figs. 13, 15) and remain in seral stage (see photo 9). The surface deposits on this slope are mostly occupied by villages and cultivated lands (Figs 13, 14). On abandoned cultivation or alluvia along the river, kail is the pioneer species and is succeeded by deodar or/and spruce. The regeneration of the blue pine is profuse on soils freshly laid bare by landslips or snow slides (Fig. 14). (3) On dip slope of micaceous sandstones, kail is the pioneer tree, being succeeded by deodar (Fig. 13) and where phyllite occurs on the dip slope, kail-deodar forests have a higher percentage of deodar and are often accompanied by spruce (Fig. 14). Spruce, however, is usually abundant on morainic deposits where it occurs in association with broadleaved species such as *Juglans regia*, *Aesculus indica*, *Prunus padus*, etc. (Figs. 15, 16). As shown in table on p. 148 mineral requirements of spruce are highest among the conifers and in this respect it resembles poplars, alder, walnut, etc., in association with which it commonly occurs. (4) The succession of tree vegetation in this area is Kail→Kail-Deodar→Spruce.

Thus, it seems that the general features of lithology and the nature of the slope of rock govern the distribution and development of the main tree communities in this area as well. The geology of this part of the valley is rather complicated on account of the thickness and extent of surface deposits. The snowy mountain tops are rounded showing the existence of a glaciation in the recent past. This is confirmed by the presence of glacial moraines at higher levels, with angular blocks often bearing scratches and marks of having been dragged under the load of glaciers. All these diverse deposits, however, do not mask the general relationship between rock types and forest communities.

(*d*) *Forests at Pulga.*—These forests are developed at lower levels on flood-plain deposits and at higher levels on glacial moraines. The rock does not outcrop on the surface except very rarely above 10,000 ft. or along nalas ; the vegetation is, therefore, governed mostly by the surface deposits. The flood-plain deposits that extend from the bank of the river Parbatti to elevations of nearly 8,000 ft. on southern side are somewhat sandy in composition. Most of these are, however, under cultivation by inhabitants of Pulga and Tulga ; on the remaining parts there are good plantations of deodar and natural vegetation of kail, deodar, spruce, and broadleaved species of *Juglans regia*, *Aesculus indica*, *Prunus padus*, etc. Fig. 17 shows a general relationship between forest growth and surface deposits in these forests.

The freshly laid deposits along the river are covered with *Alnus nitida*, *Populus ciliata*, *Aesculus indica*, etc. These are invaded by kail and *Quercus dilatata*, which spring up also on abandoned cultivation.

PHOTO 1

↑

A view from Kasol of the Parbatti Valley, showing the chir pine community on scarp faces of the quartzite formation.

PHOTO 2

→

PARBATTI VALLEY

A view of scarp face showing scattered chir pine seral community on quartzite above and final community of Kail-Deodar below on flood-plain deposits.

PHOTO 3

A close view of Kail and Deodar, colonizing flood-plain deposit of Kasol Nala near Kasol.

PHOTO 4

KASOL VALLEY

A view of scarp slope of quartzite showing bare areas, and scattered trees of the chir pine community (in a seral stage).

PHOTO 5

↑

KASOL VALLEY

A view of the dip slope of micaceous schist with a luxuriant vegetation of Kail and Deodar.

PHOTO 6

→

KASOL VALLEY

A view of Kail forests on dip slope of quartzite. Note the paucity of ground flora and shrubby layer.

Cedrela Serrata seen on left is on the adjoining band of phyllite on which there is a luxuriant growth of ground flora and shrubs.

PHOTO 7

KASOL VALLEY

A view of vegetation on scarp—and dip slopes of bands of phyllite (above) and quartzite (below). Phyllite bears Kail on scarp and Deodar on dip slope while quartzite bears chir on scarp and Kail and ban oak on its dip slope. Vegetation on scarp face (front view) is similar to that on the scarp slope.

PHOTO 8

KASOL VALLEY

Entrance of the Valley showing flood-plain deposits with Deodar on both sides.

The morainic material is mainly clayey and it occurs above the altitude of 9,000 ft. on which spruce and silver fir forests are commonly found (photos 9, 10, 11, 12). At higher levels, silver fir, with an understorey of *Taxus baccata* becomes abundant. A detailed account of the vegetation of these forests is admirably given by Suri (1933) and my observations in the light of his work show that :—

(1) The pioneer conifer on all types of surface deposit is the blue pine which is succeeded by Spruce→Silver fir.

(2) On deep clayey deposits along water courses pioneer species are *Juglans regia*, *Aesculus indica*, *Prunus padus*, *Cornus macrophylla*, etc., which are invaded by spruce and/or kail. These forests then pass at higher levels into pure silver fir or fir-spruce forests.

(3) On exposed rock matrix there occur stunted trees of *Abies* with *Quercus semecarpifolia* and birch.

Fig. 18 shows tree vegetation on flood-plain deposits in valleys of the tributaries of the Parbatti. At this altitude spruce is the final community on river alluvia. In felled areas kail regeneration is abundant and the mixture of kail and spruce is the result of human interference.

(*e*) *Kulu valley*.—Unlike Parbatti valley, this valley is wide and U-shaped having been carved by glaciers into the substrata of micaceous schist during the last Ice-age. From Kulu to Manali this feature is very prominent and the presence of morainic outwash and debris, even at lower altitudes, along mountain sides with flood-plain deposits has given this valley a characteristic configuration. The river at present is cutting its way through its own old flood-plain deposits, a series of which are seen in the valley forming terraces at different levels. These terraces are cut up by small side channels, which have formed their own fan-shaped flood-plain deposits over the deposits of the Beas river.

The flood-plain deposits and morainic material extend for long distances up on both sides of the valley and have hidden the solid geology of the area. The main rock here is micaceous schist with which sandstone may also be present locally. The dip of the strata is generally NNE. or NNW. The river flows from N. to S. Both sides of the Beas valley between Kulu and Monali, are therefore, scarp faces of micaceous schists on which kail community is usually predominant.

On new flood-plain deposits extensive groves of *Alnus nitida*, *Ulmus* spp. *Populus ciliata*, etc., are found. In older deposits, deodar and kail occur in small patches. In Fig. 19 are shown vegetation and geology in the valley near Naggar. Moraines and alluvial deposits hide the underlying rocks on eastern slopes and the vegetation is largely affected by surface deposits which provide some of the best agricultural soils of the valley. At some places deodar plantations have been very successful on these deposits. It may be interesting to note that almost all fruit orchards for which this valley is famous, occur on such surface deposits. In this respect the Kulu valley compares with the vale of Kashmir, where the surface soils though derived from glacial and lake deposits are equally rich and fertile.

A relation similar to that found at Naggar is seen at Monali and other places in the valley. The Forest Department having realized the importance of geological factor have raised successfully plantations of deodar on flood-plain deposits in the valley along the banks of Beas at Monali and at higher levels on the mountain sides. The succession of forest communities here is similar to that found in the Parbatti valley and proceeds from Kail→Kail-Deodar →Deodar. There being no quartzite or other sandy rock in the Beas valley the chir pine is conspicuous by its absence from altitudes at which it usually occurs in the Parbatti valley. On both sides in the Beas valley the blue pine is the most common tree community on scarp face of micaceous schist. On flood-plain deposits, however, kail-deodar and kail-deodar-spruce communities occur and show similar succession to that seen in the Parbatti valley.

CONCLUSIONS AND SUMMARY

From the examples studied in the Kulu Himalayas it is clear that lithology and structure of the main rocks are important factors in governing the growth and distribution of forest vegetation. The availability of minerals such as Calcium, and moisture relationship in a single bed depend upon the nature of the slope ; and plant communities are therefore intimately related to the geological slope. The exacting

communities with high foliar ash and CaO usually occur on dip slope. These very species are known to require higher amounts of soil moisture which is available on dip slopes due to seepage from other areas. The scarp slopes are either bare of any tree vegetation, or usually bear non-exacting species, with low amounts of foliar ash and CaO ; and these species generally affect dry and hot situations. Scarp slopes being leached areas are dry and consequently hotter.

In this area, scarp slopes are almost always precipitous and very steep, while dip slopes show gentle gradients. Topographically, therefore, escarpments are immature against relatively mature topography of the dip slopes. Further, scarp slopes being steep, are hotter than dip slopes due to sun's rays being concentrated on the former.

Thus conclusions drawn from this study support in a general way ideas of earlier authors who related tree communities only with the amount of atmospheric moisture, altitude and/ or aspect. As already stated, in most of the examples studied in these mountains, northern aspect usually coincides with dip slope and southern aspect with scarp slope. Thus, the favourable effects of aspect and climate, are therefore, in harmony with geological factors. In some cases where xerophytic communities characteristic of southern aspects are found on northern aspects, the relation between the rock and tree communities becomes clearer, and shows that the influence of rock is perhaps of a fundamental nature. The basic nature of the relationship between tree communities and geology is further shown by the absence of the chir pine community in its altitudinal zone from the Beas valley from where the quartzite formation is likewise absent. The presence of the blue pine at lower and higher altitudinal zones on flood-plain deposit, or on scarp slope of micaceous schist, or sandstone, is related more closely to the rock type than to climate or aspect ; as the examples studied show that both climate and aspect produce different effects for the growth of one and the same species at different altitudes and cannot be the master factors. Silver fir and spruce occur at high altitudes on all aspects on suitable geological formations and slopes.

The relationship shown between forest vegetation and geology in the Kulu Himalayas is perhaps of a general nature. Smythies (1919) found that in the Naini Tal district, geology is a predominant factor in determining plant distribution. The author's studies in Europe (Puri 1949 a, 1949 d) and in this country (Puri 1949 b and 1949 c) extend the applicability of this factor over wide areas. Thus, it may be concluded that in a broad climatic zone the distribution of forest communities in adjacent areas in a valley or mountain side is governed by the geological structure. This is more true of vegetation in colonizing stages. The effects of micro-climate become marked only when vegetation reaches stability with ecological factors, especially those of the soil.

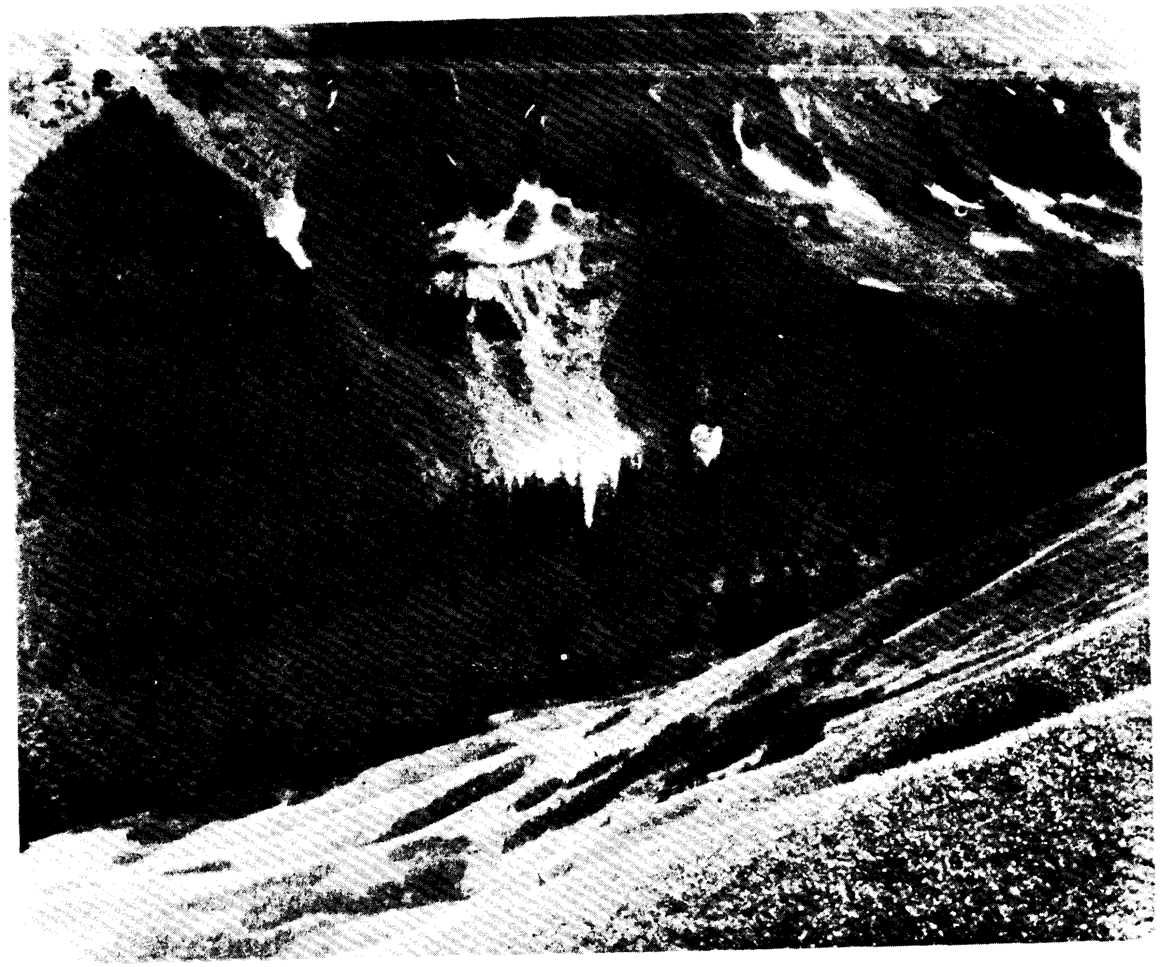
2. At lower altitudes on quartzite formation, or on flood-plain deposits the chir pine is almost always the earliest colonizer. The succession usually proceeds from the Chir pine→Blue pine →Deodar.

At higher elevations the blue pine is usually the pioneer and succession proceeds from the Blue pine→Spruce-silver fir→Silver fir. These observations are supported by data of foliar ash and CaO of tree species.

These conclusions regarding distribution and succession of conifer communities in the Kulu Himalayas are in agreement with those of earlier workers notably, Suri and Wright (1922), Suri (1933), Osmaston (1931), Mohan (1933) and Glover (1930, 1931), who laid stress on the climatic factor.

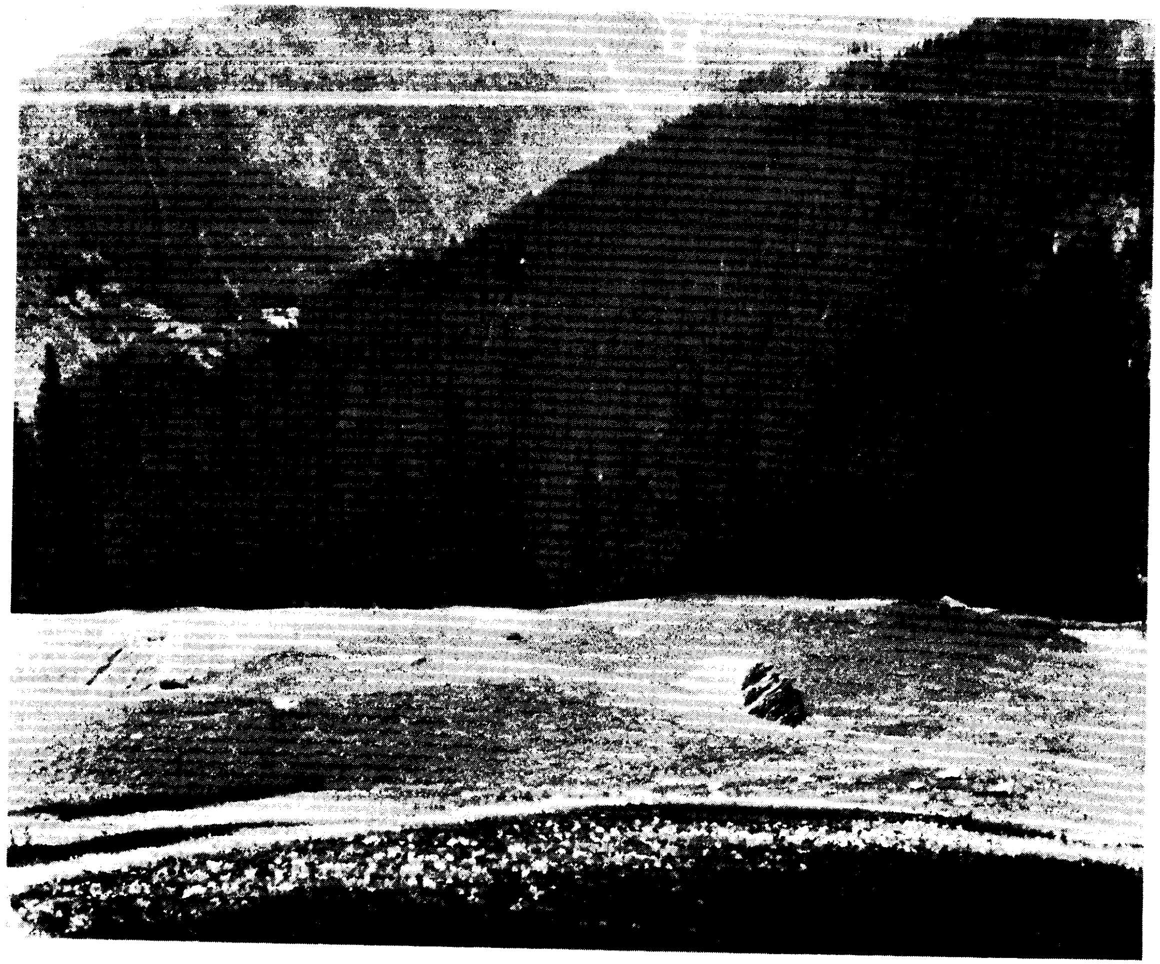
3. The ecological relationship of plant communities with their habitat clearly shows that for planting deodar, a species of economic importance in the area, the most suitable sites are flood-plain deposits or dip slopes of phyllite. Quartzite formation, or scarp slopes of schists and phyllites are unsuitable sites for this species, but would be suitable for the chir pine or the blue pine and these communities would, perhaps, not be succeeded by the deodar community but would remain in pure developmental stages. There exist large stretches of ecologically suitable areas in the valley for plantation of deodar which, if the Forest Department considers necessary may be used with best advantage.

PHOTO 9



A view of Pulga forests near Bandag spruce lower level and Silver fir at higher level. Note conical strips of forest growth; scree talus below snow in the middle. Foreground middle circular patches of a fern. Right bottom herbs in flowers.

PHOTO 10



A view from Swagni Maidan 10,000 ft., looking SE. Left-Scarp slope with Kail and Right-Dip slope with Silver fir—Foreground pasture on a glacial moraine, note transported stratified blocks of Rock.

A view from Swagni Maidan looking SE. Trees of Silver fir in the foreground and stratified block of rock which has been brought here by glaciers. Left-Scarp slope with Kail Right-Dip slope with spruce forests.

PHOTO 12

A view looking NE. from Swagni Maidan showing snowy peaks of schistose rock with Kail at lower levels on scarp slope. Opposite side with Silver fir and spruce on moraine. A part of moraine with flowering herbs in the foreground.

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APPENDIX

Chir pine	*Pinus longifolia*
Kail or blue pine	*Pinus excelsa*
Spruce	*Picea smithiana*
Silver fir	*Abies webbiana*

CORRECT NAME OF INDIAN SILK-COTTON TREE (*SEMAL*)

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The Indian silk-cotton tree, commonly known as *Semal, Simul, Simuri, Sembal,* etc., is found from the Himalayas to Ceylon and extends to the drier regions of Malaysia and perhaps also to Australia. Its large red flowers with many bundles of stamens make the plant conspicuous during February and March when the trees are without any leaves. In Sanskrit literature it is called *Salmali* from which most of the common local names are derived. The earliest botanist who described this plant appears to be Rheede who figured and described the plant in 1682 under the name *Moul Elavou.* Although this plant has received attention from botanists for a long time, its correct botanical name appears to be still somewhat obscure. As a result, three names are currently used, for one and the same plant. The commonest name, and the one most widely known, is (1) *Bombax malabaricum* DC. (used as recently as 1950—Proc. Indian Science Congress—Abstracts Part III, 52). The second name is (2) *Gossampinus heptaphylla* Bakh. This was also recently noticed in *Blumea 6* : 250 (1947–48). The third and correct name, used less frequently (recently used in Lowson and Sahni's Text-book of Botany, Seventh Edition, 1949, p. 345), is (3) *Salmalia malabarica* (DC.) Schott et Endlicher.

The subject of the correct name of the Indian Silk-cotton tree was first discussed by Bakhuizen* and later by Furtado†. Bakhuizen who monographed the family *Bombacaceæ* to which our plant belongs, accepted the name *Gossampinus heptaphylla* Bakh. Furtado after an admirable discussion accepted the name *Salmalia malabarica* (DC.) Schott et Endl. Both the authors have rejected the more popular name *Bombax* on the ground, that strictly speaking, the genus *Bombax* is restricted mainly to plants from Tropical America. A suggestion as to the use of the name *Bombax* for the Asiatic species has, however, been made again recently by Miss M. L. Green, to which reference will be made later.

Furtado's paper is not easily available to the numerous Indian botanists and forest officers and it therefore seems desirable in this review, to discuss in brief the present position and to include certain other additional information hitherto not available in either Furtado's paper or in Bakhuizen's monograph. In the preparation of this note we have received some help from Furtado's paper (l.c.).

BOMBAX

1. The generic name *Bombax* was accompanied by names and descriptions of three species at the time of publication by Linnaeus (Sp. Pl. 511 ; 1753). Two of these, were soon transferred to other genera, i.e., *Ceiba* and *Cochlospermum.* The third species, i.e., *Bombax ceiba* Linn., which represented an American plant should, according to article 51 of the International Rules of Botanical nomenclature, form the type of the generic name *Bombax* and be permanently associated with it.

2. One of the synonyms of *Bombax ceiba,* however, happened to be *Moul Elavou* of Rheede—an Asiatic plant. According to the rules the major part of *Bombax ceiba* Linn., should form the type of the genus *Bombax,* and a name has to be found for the residue which happens to refer to the Asiatic plant.

GOSSAMPINUS

3. In 1827, Francis Buchanan (afterwards known as Buchanan-Hamilton) called this plant *Gossampinus rubra*‡. Unfortunately, he did not give a generic description of his new genus *Gossampinus,* but merely stated that he had earlier expressed his views on this plant.

* Bull. Jard. Bot. Buitenzorg *6* : 161 (1924).
† Gard. Bull. Str. Settlem. *10* : 173 (1939).
‡ Trans. Linn. Soc. *15* : 125 (1827).

Evidently this referred to his earlier paper in Mem. Wern. Nat. Hist. Soc. *5* : 377 (1824). A study of this paper shows that here too he did not clarify his views about the generic name nor had he given a generic description. The generic name *Gossampinus* was thus invalidated until 1832 when Schott and Endlicher validated the name by supplying a description in Melet. Bot. 35 (1832). They, however, did not include the Asiatic plant under this genus but included another plant. Therefore the name *Gossampinus* cannot be accepted for the Asiatic plant. Regarding the use of the specific epithet in *Gossampinus heptaphylla* by Bakhuizen, it may be stated that it was derived from *Bombax heptaphyllum* Houttuyn. Unfortunately, however, being a later homonym, the epithet becomes invalid under the rules and should not have been used.

SALMALIA

Schott and Endlicher simultaneously (*l.c.*) described another genus *Salmalia* and based it on the Asiatic plant commonly known as *Bombax malabaricum* DC., and this name should be considered as the correct name for the Asiatic plant as shown below :—

Salmalia malabarica (DC.) Schott et Endlicher, Melet Bot. 35 (1827).

Bombax malabaricum (DC.) Prod. *1* : 479 (1824).

Gossampinus rubra Buch-Ham. *in* Trans. Linn. Soc. *15* : 128 (1827).

Bombax ceiba Linn. *partim* Sp. Pl. 511 (1753).

Bombax heptaphyllum Houttuyn *non*. Linn. Handleiding Pl. Kruid K. Linn. *3* : 153 (1775) ; Cav. *non*. Linn. Diss. Bot. *5* : 296 (1788) ; Roxb. *non*. Linn. Cor. Pl. *3* : 43 tab. 247 (1819).

Gossampinus malabarica (DC.) Merr. in Lingnan Science Journal *5*: 126 (1928); D'Almedia *et* Correa in Journ. Bomb. University *17* : Sec. B. 23 (1949).

Moul Elavou Rheede, Hort. Malab. *3* : 61 et tab. 52 (1682).

Although the non-applicability of the names *Bombax* and *Gossampinus* for the Asiatic plant is clearly shown above, it is surprising to find that Miss M. L. Green has suggested in the list of British Proposals (p. 160) that a much later name *Bombax malabaricum* should be considered as the type of the genus *Bombax*. This has been already objected to by Furtado and we agree with him. It is necessary that the following proposal be considered at the Nomenclature Section of the International Botanical Congress at Stockholm this year.

Proposal.—"The genus *Bombax* is already typified by *Bombax ceiba* Linn. (*pro maxima parte*) and should continue to be so. Miss M. L. Green's proposal (in proposals by British Botanists, p. 160) that the genus should be typified by a much later name, i.e., *Bombax malabaricum* (DC.) may be rejected, as it is against the principle of Article 51 of the International Rules of Botanical Nomenclature".

*Pathological Note No. 4**

TOXICITY TESTS BY WOODBLOCK METHOD

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CASHEW SHELL OIL

Introduction.—According to Burkill (1) the tissues round the kernel of cashew nut *Anacardium occidentale* Linn. contains considerable quantities of Cardol and Anacardia oil which is exceedingly irritant. Watt (2) refers to this oil as Cardol or cashew apple oil. It is black, acrid and perfectly vesicating. In the Andamans it is used to colour and preserve fishing lines. It is an effective preservative against white ants in carved woodwork, books, etc. The pericarp of the nuts produces a black acrid oil, Cardol.

Methods.—Experiments were conducted to test the toxic properties of cashew shell oil with a view to find out of this oil which is highly astringent to animal tissues can be effectively used as a wood preservative against the attack of wood rotting fungi.

The laboratory method of testing wood preservatives on woodblock media as described by Findlay (3) and accepted by the British Standard Institution was adopted for the tests. Sal blocks of size $2 \times 1 \times \frac{5}{8}$ inches of uniform sap-wood free from fungus were used for the impregnation of the chemicals. The long-necked type of Kolley's flasks according to the specification of the British Standard Wood-block tests of Toxicity of Wood Preservatives (4) each containing 65 cc. of 2% Kepler's malt extract agar media was used for these tests.

The Test Fungus.—*Polystictus sanguineus* (L.) Mey. which is a common sap rot fungus of the hardwood species in the tropical and sub-tropical regions was used as the test fungus. This fungus causes an average 40% loss of weight of sal sap-wood at the optimum temperature of 35°C under 4 months' test. It is easy to work with this fungus, as it transfers well, is easily activated and keeps up its vigour of growth when maintained on artificial media for any length of time. It is active on timber containing 40% of moisture.

P. sanguineus gives positive oxidase reaction with tannic acid malt agar.

Cultural Description of P. sanguineus.—*P. sanguineus* (L.) Mey. grows in a radiating fan-shaped manner on malt agar media. The growth begins between 36 to 48 hours after inoculation, first as appeared, then produces wooly-cottony aerial hyphæ. The growth advances after 72 hours at the rate of $\frac{3}{4}$ to 1 cm. every 24 hours, at the optimum temperature on malt agar media of pH 6·8 to 7 and covers the media of 12 cm. diameter in 10 to 12 days. In the course of the advance of growth a hyphal mat is formed due to the condensation and thickening of the appressed and aerial hyphæ ; and also zonations in the mat become distinct due to the formation of rings alternately composed of short stapled appressed and wooly-cottony aerial hyphæ. The colour of the mat changes to pink at this stage, and after 10 days of growth the colour of the entire mat changes to red, sometimes uniformly, occasionally in unequal quadrants, but generally in patches, except at the advancing margin where the hyphæ retain their original white colour. Cushions of carmine red colour are formed on the raised thick mat in 4 to 6 weeks. These later on form the bases of abnormal sporophores. On the media in the test flasks, the fungus can be kept active for six months under optimum conditions, though it can be maintained for a much longer period at a lower temperature. At 22°C which is 10° below the optimum temperature, the fungus can be maintained for at least 12 months on slants in tubes containing 20 cc. of malt agar.

* Pathological Note No. 3 appeared in our issue for July 1947.

FOOTNOTE :—

(1) 1935, Burkill, I. H. A Dictionary of the Economic Plants of the Malayan Peninsula, p. 144.
(2) 1885, Watt, George A Dictionary of the Economic Products of India, Vol. 1, p. 232.
(3) 1932, Findlay, W. P. K. Laboratory Methods for Testing Wood Preservatives: Ann. of Appl. Biol. Vol. XIX, 1932, p. 27.
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The characters of the growth on the woodblocks can be compared to that of a malt agar plate, but the progress of the fungus depends on the moisture content of the wood. If the moisture content remains over 40% the activity of the fungus is greatest as shown by the actual loss of weight of wood under the fungus infection. The colouring appears sooner and is more intensified on the blocks than on the agar media.

Experiments on sal sap-wood blocks treated with cashew shell oil.—Blocks treated with four concentrations of cashew shell oil, viz., 5%, 10%, 20% and 50% were exposed to *P. sanguineus* for 18 weeks at 33°C.

For the toxicity experiments the treated woodblocks are not sterilized prior to fungus infection. Occasionally, however, such blocks are quickly passed through a flame just to submit them to surface sterilization, to kill the mould spores which remain attached to the blocks, if the blocks are dried in the open after treatment, a constant source of trouble in tropical countries. In these experiments with cashew shell oil, specially at the lower concentration 5% and 10%, this quick flaming did not safeguard the mould infection on the blocks. The mould growth appeared with 72 hours of introduction on the media.

Experiments were also conducted to find out if the oil contains viable spores of mould. For this purpose the 10% concentration of cashew shell oil was tested. Streaks of this sample of oil were drawn on the malt agar slants by a sterile platinum needle and the tubes were incubated. Growth of mould appeared along the line of the streaks between 48 to 72 hours in all the slants.

The last two sets of blocks under experiments with the higher concentration of cashew shell oil, namely, 20% and 50% were sterilized in the autoclave for 15 minutes, each block was wrapped separately with oil paper for protection from moisture and leaching out of the oil as far as practicable.

The blocks were introduced in the flasks after 7 days, when the agar plate was fully covered by the fungus. Glass benches made of 2 mm. diameter glass rods were used for the resting of the treated blocks on the fungus mat. Sterilized distilled water was introduced by means of a sterile pipe in the bulbous neck of the flask once a month during the dry season, and in alternate months or after a longer period during the wet weather.

The rate of growth and progress of fungus on the treated blocks.—The rate of growth on the blocks treated with 5% and 10% cashew shell oil was almost the same as that on the untreated controls. The blocks were covered with thin growth of floccose hyphæ in 10 days. The mat thickened during the following 2 weeks and the original floccose hyphæ were transformed to wooly-cottony hyphæ and a thick mat was produced. First a few patches of pink appeared on the cushion-like growth on mat covering the blocks, but later on the colour was intensified into carmine red Shallow pore tubes were also formed on the coloured cushions six weeks after the introduction of the blocks.

The progress of the fungus on the blocks treated with the higher concentrations namely 20% and 50% was slow from the beginning. By the time the fungus fully covered the blocks treated with the lower concentrations it only ascended along the lower surface of the blocks treated with the higher concentration of the cashew shell oil. In six weeks the fungus produced a thin growth of floccose hyphæ on these blocks. The fungus, however, gained vigour after 6 weeks and thick mat was formed on the 20% treated blocks and carmine red coloured cushions were also formed. On the 50% treated blocks the growth of the fungus was slower still. The fungus produced a patchy growth of floccose hyphæ in 6 weeks. After 8 weeks a thin mat was formed consisting of floccose to wooly-cottony hyphæ. The progress appeared slow even at this stage, and after 10 weeks a definite mat was formed only thick enough to obliterate the colour of the wood underneath. The colour of the mat on these blocks changed to pink and red in patches, but neither the cushions nor the carmine red sporophone initials were seen on these blocks.

After 18 weeks while the fungus remained vigorous on 5% and 10% treated blocks, on most of the 20% treated blocks it appeared merely active up to the 16th week. In the case of those treated with 50% the vigour of the fungus weakened after 16 weeks.

Evaluation of results.—It is apparent from the rate of growth that the activity of the fungus on the 20% and 50% treated blocks was less than that on 5% and 10%. The formation of

mats and the abnormal sporophores are the external manifestation of the fungus activity. The formation of such sporophores was suppressed on the blocks treated with 50% cashew shell oil. It was expected that the loss of weight of wood would also be proportionate to the apparent vigour of the fungus on the blocks. But contrary to expectations it is seen from the table below that the loss reached its maximum (55·8%) and the highest average (25·3%) with 20% treated blocks and this maximum is even higher than the average (44·2%) of 24 controls.

TABLE

	Loss of weight of wood after 18 weeks tests at 33°C		
	Maximum	Minimum	Average of 24 blocks
5% treated blocks ..	33·9%	10·0%	19·4%
10% treated blocks ..	24·3%	7·1%	16·9%
20% treated blocks ..	55·8%	3·6%	25·3%
50% treated blocks ..	45·4%	5·7%	23·8%
Controls	58·9%	32·7%	44·2%

There are two factors which may explain this anomalous result. Firstly, the last two sets of blocks treated with the higher concentrations were autoclaved, though for a short time. Some percentage of oil may have volatilized or leached out from these blocks ; or the 20% cashew shell oil may have a stimulating effect on the fungus inside the wood while the higher and the lower concentrations have the opposite, i.e., deterrent effect. It is, however, difficult to explain all such phenomena particularly those that stimulate the fungus growth and activity.

The nett result of these experiments proves that cashew shell oil, however, astringent to the animal tissues is not a suitable wood preservative against fungus rot.

[The writer wishes to acknowledge the help of Dr. Narayanamurthi, Officer-in-charge of the Wood Preservation branch for supplying blocks of Sal Wood with two concentrations of cashew shell oil, and the data on the loss of weight after the tests].

INDIAN CANES (RATTANS)

BY S. RAMASWAMI

SUMMARY

Contains a short note on canes with special reference to preparation of the canes for the market and artificial regeneration. The use of canes as raw material in cottage industry is emphasised.

Canes are trailing or climbing palms belonging to the tropical family Palmæ, with over two hundred species included under the genus *Calamus* (1*a*). They have a wide distribution in the tropics : they are found in the Indo-Malayan region, Sumatra, Java, Borneo, the Philippines, New Guinea and Australia ; several species also occur in tropical Africa, in the Congo region. In India cane brakes are found in moist places at the edge of swamps or banks of rivers in the forests of Assam, Bengal and Malabar. They are comparatively rare in the rest of India where they may occur in small quantities in suitable moist places.

Canes are used locally by the inhabitants wherever they are found, but the canes entering the world trade always used to come from the Malay Peninsula : and Singapore canes have always been considered to be the best. India has been importing canes from Malaya for a long time to supplement her local resources ; but after the fall of Singapore during the Second World War, Indian canes have been finding an increasing foreign market, as the following figures show (1*b*) :—

Imports of Canes into India*

	1925–26	1930–31	1935–36	1941–42	1942–43	1943–44	1944–45	1945–46
Quantity in cwt. .	38,072	33,855	27,729	41,903	557	..	..	339
Value in Rs.	5,07,753	4,74,622	3,20,403	7,42,139	15,770	..	..	17,011

* The bulk of the imports were from the Federated Malay States.

Exports of Canes from India

	1925–26	1930–31	1935–36	1941–42	1942–43	1943–44	1944–45	1945–46
Quantity in cwt. ..	1,201	1,127	854	1,374	7,583	14,112	11,046	18,575
Value in Rs.	50,131	37,558	40,770	32,854	1,82,849	4,41,211	4,60,073	9,17,084

Large quantities of canes are also consumed in India, but no figures of consumption are available. Though numerous species of canes are found in Malaya, only half the number are of economic importance ; and amongst them the species that enter the world trade are relatively few. The two commercially important genera are *Calamus* and *Dæmonorops*.

Canes are first erect and small for the first few years and then start climbing ; one or several shoots may arise from a single root, this being an important character. A few species remain as a bush throughout their lives. Very little is known about the regeneration, rate of growth, silvicultural requirements, etc., of canes found naturally growing in forests. There are no cane plantations in India and commercial supplies of Indian canes come from naturally grown plants. Based on local observations, canes are cut once in three years in Assam (2*a* & *b*), Bengal (3) and in Puri Division, Orissa (4) ; in Nilambur valley, the right to

cut canes is leased on alternate years (5). In Bahraich Division in U.P. (6) and in Sriharikota Range, Vellore District Madras (7) canes are cut on a three year rotation.

EXPLOITATION

In the world trade Singapore cane is considered to be of first quality : Indian canes are inferior. This is because in India no special attention is paid to the preparation of the cane after it is cut. Cane contractors who are interested only in immediate profits, cut and market immature stems and also the portion near the tip of even mature stems ; these discolour readily, are brittle and shrink badly and when they are mixed with mature stems, the quality of the whole lot is lowered in the eye of the trade. Moreover, the Indian canes are not properly dried or seasoned before being put on the market ; for this reason Indian canes have rarely the same good appearance as the Malayan ones.

If the same attention is paid to the preparation of the canes in India, after they are cut, as is being done in Malaya, the quality of the Indian cane could be considerably improved.

The collection of canes from the jungles in Malaya is done entirely by the Chinese (8). The professional collector sets up his camp near a stream and clears up sufficient surrounding cover to enable him to dry the canes he has collected. This is important, as undried canes deteriorate very quickly and if the weather is wet, the canes are dried over a fire. The canes from the Dutch East Indies were originally shipped undried to Singapore, but as this was found to affect the colour and quality of the canes, and hence the prices obtained, the collectors started drying the canes themselves in the jungles, as soon as they were cut.

The collector selects his plant because of its size, length, strength and colour, and often collects only a single kind (9). Only the mature stems are taken and they are cut at the base. Immature stems are not cut, otherwise, the plant will die ; moreover, immature stems discolour, shrink and are brittle and generally inferior in quality. Even in the mature stem, the top 6 feet from the tip are cut and rejected, as being of poor quality. After cutting, the canes are pulled, generally between two branches of a tree so that a rough cleaning of leaves also takes place at the same time. The rough cleaning is also done with a knife. They are cut to 16 ft. lengths, scoured with sharp sand, washed with water and thoroughly air dried. After this process, any immature stems found mixed with the lot are carefully removed. During the process of drying, canes shrink both in volume and in weight. The cut pieces are folded once, bundled in 50 or 100 and sent to Singapore.

At Singapore the canes are sorted into grades and given certain special treatment. Those with a natural glaze are "luntied"—rubbing the cane about a post between two pieces of bamboos, with a twisting motion. When this is over, the cane is washed in running water, scored with sharp sand, laid in the sun to dry, bleached with sulphur fumes and then taken to the warehouse and sorted into grades, based on the length and diameter of the internodes and uniformity. They are then packed for shipment as before. Under one trade name several kinds are included.

UTILIZATION

Canes vary in thickness from $\frac{1}{8}''$ to the thickness of a man's arm and in length from a few feet to 200 feet or more. Some attain lengths of 500 to 600 feet and even a length of 2,000 feet has been recorded in Borneo (10). Thick ones in the round are used for furniture frames, basket ribs, broom handles, sewer rods, walking sticks, polo sticks, ski-sticks, snow brooms, etc. The thinner ones are generally split and used for chair seats and in basketry work.

Splitting of canes.—The cane consists of a hard, shiny outer portion with a deposit of silica and a comparatively softer inner portion, popularly known as the "pith". During the process of splitting the outer layer is separated off from the "pith" in the form of long narrow strips and these strips are used in making chair bottoms and in basketry work. There is considerable demand for split canes in European countries and the process of splitting is done with the help of machinery, mostly in France and in Germany. Though the process is called splitting, it is really peeling. The long strips thus produced are planed and trimmed by machinery and delivered as flat strips for use in making chair bottoms. The "pith" is then cut by machinery into long strips, square, round or flat in section and sold to manufacturers for making various plaited articles.

In India cane splitting is done by hand by professional cane workers with the help of special knives ; it is a laborious process and they split only just enough to meet their own requirements.

CANE WORKING AS A COTTAGE INDUSTRY

The cane is an ideal raw material for cottage industry work. Apart from a few hand tools no costly machinery is required. The art is easily learnt and women and children can do it in their spare time. There is a wide demand for baskets, etc., made of cane. The industrial schools and refugee camps in different parts of the country can easily be made centres for training in this work.

For organizing this industry the following points deserve special attention :—

(1) *Supply of raw material.*—Large supplies of canes can be obtained by writing to the following officers :—

The Chief Conservators of Forests, Assam, Shillong ; Bengal, Darjeeling ; Madras, Madras, Travancore-Cochin, Trivandrum ; and Bombay, Poona.

Smaller supplies can be got through :—

The Chief Conservators of Forests, U.P., Naini Tal ; Madhya Pradesh, Nagpur ; and Bihar, Patna.

The Conservator of Forests, Orissa, Angul.

(2) *Preparation of the raw material :*—As soon as the canes are cut in the jungles, they should be thoroughly seasoned (dried), according to the Malayan practice, as already mentioned in this note. Careful attention to this detail, preserves the colour and elasticity of canes.

(3) *Splitting of canes :*—This is a process which all cottage workers, especially women and children, cannot do themselves. Industrial schools and refugee camps should employ professional cane workers for splitting the canes and the split material should be supplied to the cottage workers. At the same time, different patterns should be supplied to different workers, so that no glut in the market is created for the same type of finished product.

(4) *Marketing of the finished product :*—The cottage worker is not in position to send his finished products to distant markets. The centres which supply him with the raw material should also arrange for the marketing of the manufactured product. They should also study the particular demands of different products and pass on the ideas to the cottage workers, so that the articles made by the cottage workers are always in great demand. This is the practice in Japan, where cottage industries are very highly organized (11).

CANE PLANTATIONS

India's exports of canes have been increasing steadily since the fall of Singapore during the last World War, and in 1945-46, according to the latest figures available, 18,575 cwt. valued at Rs. 9,17,084/- were exported from India. In addition, considerable quantities of canes are consumed in India. No information is available regarding the quantities of canes available from the forests of India, natural regeneration of canes or the rate of growth of natural canes. Mostly they are cut once in three years from accessible localities, and when these become exhausted at no distant date, our cane supplies will become precarious. The necessity for starting plantations of canes is, therefore, obvious.

Canes are generally found to occur near about watercourses, and in such regions there are very few economically useful timber trees. Such localities can usefully be converted into cane plantations. Apart from a few haphazard attempts no work has been done in India on artificial regeneration of canes. In 1932-33, a supply of cane seeds was obtained from the Federated Malay States for propagation in South Arcot and Nellore districts in Madras, but the seeds failed to germinate (12). The Working Plan of Bahraich Division, U.P. mentions that "if possible, canes should be extended by putting in cuttings along sides of suitable *nullahs*". It is not known whether this was attempted, and if so, with what results. The Working Plan for Sriharikota Range, Nellore District, Madras for 1932–42 says that attempts to introduce better varieties of canes will be made with seeds obtained from the Straits Settlements. Was this done ?

It is suggested that all States in India, where canes are naturally found, should make experimental cultivation of canes in suitable localities. Details of the Malayan practice in raising cane plantations, are, therefore given below (8) :

The first plantations of canes (rattans) *Calamus cæsius*, in Malaya were made by missionaries about 1850. The seedlings are raised in nursery beds, under shade, seeds being sown 5 or 10 cms. apart, covered with a light layer of soil and kept well watered. Germination is slow. Sometimes seeds are freed from shell and pulp by treading them in a basket with plenty of water. Seeds germinate in 14 days. When the seedlings are 10 to 20 cms. high, they are planted out in wet weather, 2 feet apart, in rows 30 feet apart.

Soils water-logged or subject to frequent inundations are useless. *Calamus cæsius* grows naturally in well-drained soils in light forest, along banks of streams and fresh-water swamps and this type of country should be chosen. Paddy is frequently grown first in such localities and cane seedlings are introduced with the last crop of paddy.

The supporting trees should be strong enough to support considerable weight and tough enough to withstand pulling when canes are gathered. Species with spreading surface roots are not desirable. Overhead cover should not be too heavy ; otherwise growth will be feeble. When plants have established themselves, very little attention is required beyond occasional loosening of the soil round the clumps and mulching the clumps with leaves or good earth to encourage the development of new shoots during the monsoon.

The plantation begins to yield utilizable canes in about six years, but come into full bearing about the fifteenth year, by which time there should be 50 or more stems per acre, with a length of 80′ to 110′. One-tenth of these can be cut every 2 or 3 years. About 6 feet from the tip, even in mature stems is useless ; hence there is a definite advantage in cutting long lengths. The surest signs of ripeness are the loosening of the leaf sheaths and the exposure of the lowest part of the stems.

CHOICE OF SPECIES

In the cane trade the Malayan canes are considered to be superior and the Indian ones inferior. This does not mean that all the Malayan species are good and that all the Indian ones are bad. Even in Malaya, out of a large number of species of canes, only a few are of economic importance, and these are subjected to special treatment to ensure the high quality, as mentioned earlier in the note. If the Indian canes are prepared in a similar way for the market and graded properly, the quality of the Indian canes can be considerably improved.

For planting purposes, it is therefore not absolutely necessary that only Malayan species should be used. By all means let us use them if sufficient seeds are available and if they are suitable to the locality. If not, let us start plantations of the economically important Indian species. A list of the more important Indian species of canes is given below :—

ASSAM

- *Calamus tenuis*. Commercially important.
- *Calamus anthospathus*. Climber with thick stems.
- *Calamus guruba*. Climber with slender stems.
- *Calamus latifolius*. Climber with stout stems.
- *Dæmonorops jenkensianus*. Climber, stem thick.

BENGAL

- *Calamus guruba*. Climber with slender stems.
- *Calamus viminalis*. Large climber with thin but strong stems.
- *Calamus latifolius*.
- *Calamus tenuis*.
- *Dæmonorops jenkensianus*.

U.P.

- *Calamus tenuis*.

ANDAMANS

- *Calamus andamanicus*. Large climber with stout stems.
- *Calamus viminalis*.
- *Calamus kurzianus*.

SOUTH INDIA

- *Calamus rotang*. Commercially important.
- *Calamus pseudo-tenuis*. Extensive climber with slender stems.

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THE WOMEN'S PART IN THE FOOD PRODUCTION DRIVE

BY F. L. BRAYNE

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(*By kind permission*)

Sir John Boyd Orr has told us that the world must double its production of food in the next twenty-five years, or starve. This is a very terrible threat but we know it is true. Many millions of people in many countries are already underfed for part of the year and some of them are underfed all the year round.

AUGMENTING FOOD SUPPLY BY SIMPLE MEANS

What is the prospect in India and Pakistan ? Besides barrages, canals and hydro-electrics and the big things which Government alone can tackle, there are innumerable small things which the experts and scientists have worked out for us. They require very little capital but a great deal of hard-work, enterprise, knowledge, co-operative effort and a lot of thrift and saving. What effect would the doing of all these small things have on the food supply ? The late Sir Albert Howard of Indore compost fame, used to say that if people would only do the simple things recommended for the improvement of soil, water supply, cattle and crops the produce of the soil could be multiplied by three.

May I give a list of some of them ?

(1) The stopping of erosion by (*a*) stall feeding live-stock with food crops, ensilage and grass cut and carried from the pastures ; (*b*) levelling and embanking all *barani* arable land.

(2) Repairing, and if necessary putting bores into, and using for both harvests, all wells ; better use of canal water, smaller *kiaris* (compartments), clean straight channels, etc. ; and using all *jheels* and other monsoon water for irrigation.

(3) Using the waste water from wells, houses and places of worship for growing vegetables.

(4) Manure pits round the village ; hay boxes instead of burning cow-dung ; composting all vegetable waste ; green manuring.

(5) Good seed, good ploughs, harrows and other tools.

(6) Sowing seed in lines, ridging, roguing, weeding, etc.

(7) Simple pest control—light traps ; washing seed ; destruction of rats and parrots, etc.

(8) Selective breeding of live-stock.

(9) Quarantining for ten days all new animals before allowing them to join the others.

(10) Using the co-operative organization wherever possible.

The list could be greatly extended but is long enough to show what I mean. They are all terribly simple things but if they were all put into use everywhere they would change the face of the country. Not all of the crops would be food crops but there would be enough to satisfy Sir John Boyd Orr's demand for doubling the food supply.

NO EASY TASK

If it is all so simple what is the fuss about ? Surely the people have only to be told about these things, to rush out and do them ? Not a bit.

Wherever one goes the story is the same. The people won't take to these new things. They are quite happy as they are and will not do the extra work required, nor will they give up their pet extravagances—weddings, feasts, silver ornaments, litigation and so on—in order to save money to buy good seed, good ploughs, stud bulls, new tools, or whatever it is that is needed to improve their outturn. In fact their idea of a high standard is less work and occasional bursts of extravagance at weddings and so on, and when we suggest that they should work harder and save and scrape in order to grow more food and be better off they think we are attacking their standard of living instead of trying to raise it.

THE PROBLEM

What is the answer to this conundrum ? How are people to be persuaded to do these things ? What incentive, what stimulus can be found to move them to action ?

It has hitherto been rather assumed that all that is necessary is to tell people of the new

and better ways of working and living and they will automatically adopt them. That may be so in countries with a generally high standard of living which every one is ambitious to achieve or to maintain but it is far from being so among people whose standard is low and where malnutrition is common. In fact the very opposite is the case. To produce more food, to improve health and to raise the standard of living requires very hard-work, much saving and scraping, much self-denial and a complete break with old custom and traditions. To do all this requires high morale and an extremely powerful incentive. Where is the incentive among people who are poor and undernourished, sunk in debt, and riddled with malaria, hook-worm and other diseases that come from dirt, squalor and malnutrition ?

Debt is no incentive. Debt bothers no one ; it is normal and natural. Besides, the debtor fears that the only person who will benefit by his extra work will be the creditor. Hunger and ill-health are no stimulants to harder work. They produce the very apathy we are fighting.

SOLVING THE PROBLEM

What then is the answer ? Treated as an economic problem there is no answer. If we wish to escape starvation we must tackle the conservatism and apathy of the people not as an economic but as a social problem. The only hope of producing an incentive that will beat the desire for less work and occasional extravagance and will overcome the placidity of malnutrition and ill-health is to design a new way of life that is better than the debt and poverty, with their occasional feasts, and the ever-recurring hunger, dirt, discomfort, ill-health and squalor which his present way of life involves.

Having painted a picture of the new life—all can join in the task—we must not only convince ourselves but we must convince the peasant, that it is better than his present way of living. Such a picture was painted for the sepoys of the Army during the last war. It was based on the work of Government Departments and of many pioneers, official and non-official, and was used for the pre-release training of the sepoys. It is described in many Army pamphlets.

THE ROLE OF WOMEN

I said that we must convince the peasant that a better life is possible. That is not quite accurate. The standard of living is the standard of the home and the standard of the home is the standard of the housewife, the 'gharwali' who keeps it. It is she who must be enlisted in the campaign for better food and better living. All through nature, the strongest instinct of the female is the well-being of its family and that instinct must be developed and exploited. Once a mother is convinced that vaccination will save her child from small-pox, can you imagine her hiding her child from the vaccinator or going to the temple of the goddess of small-pox for charms ? Once she knows what is good for her children she will insist on getting it.

Years ago at the National Institute of Agriculture in Rome, a Minister of the Belgian Government read a paper in which he proved that in a country of small farmers like Belgium, the women are responsible for more than two thirds of village life. They run the home and bring up the children, they make and mend the clothes, they cook the food, they keep the family in good health and they make the home comfortable and happy. Everything that makes home worth living in is in the hands of housewife, and it is she who must provide the incentive we are looking for.

To become prime-movers, however, in raising the standard of living the women must have far more knowledge than they have now. Not only must they have suitable education but they must have proper domestic training. Both in the schools and colleges and in the Women's Institutes or the co-operative society (why not have Co-operative Women's Institutes ?) they must be taught everything there is to know about running a house and making it nice, cooking a balanced diet, keeping a family in good health and good heart, making and mending clothes, and the hundred and one other things which every village housewife should know.

The men have big departments to teach them how to run farms and keep cattle. The women must also have big departments to teach them how to run homes and keep families.

Once the village women have this knowledge they will be forever striving to make their

homes lovely, and they will compete with each other, not in the weight of their ear-rings but in the brightness of their homes and the happiness of their families.

The women will then encourage their good men to grow the best crops or to carry on their craft in the best way possible. Why ? Because they want just one more thing, a sewing machine perhaps or mosquito nets, or whatever it is, to make home better. And each new thing will lead to another new thing. Our battle is won—the ambition for a higher standard of living has come upon the peasant and he will work hard and willingly to achieve his ambition.

The good wife will ask for the right vegetables, fruits and crops for the needs of the family, she will keep her good man in health. She will store the grain he brings where damp, rats, mice and weevils will not waste it, she will prepare the food so as to get its full value and waste nothing.

Best of all, the home will be a progressive force. At present it is the citadel of ignorance, superstition and conservatism. When a man is advised to change an uneconomic or unhygienic custom he now says his wife won't let him. Once the wife is educated and trained he will no longer be able to say that. His wife will encourage him to try new things. 'I am trying a hay-box' she will say 'and I have a new and better way of making the baby's clothes. You too must make experiments'.

All over the world it is difficult to persuade peasants to try new things. Where the women are uneducated and untrained it is more than difficult—it is impossible. The key therefore to the success of the food production drive is to design a better way of living and bring the vision of it, literally to every home in the land. The women, no less than the men—and the girls no less than the boys, at school—must be so educated and trained that they will be convinced that it is so much better than their present manner of living and is so obviously possible to achieve, that they will gladly do all the work, the saving and scraping, the self denial and the abandonment of bad customs and prejudices that are necessary to bring their vision to life in thier homes.

The defence against dry-rot. A demonstrator shows the correct method of applying preservative to building timber.

What happens when timber is attacked by dry-rot is shown in this photograph of floor joists. The picture appears in an exhibition at the Building Centre, Conduit Street, London, England, organized by Britain's Department of Scientific and Industrial Research. The object of the exhibition is to suggest the most effective methods of detection and prevention of this scourge of building timber.

By courtesy of British Information Services

PRESERVING TIMBER

Exhibition Shows how Britain is Countering Dry Rot Danger to Homes

BY LANGSTON DAY

Among materials likely to be scarce in many parts of the world for some years is building timber. Britain, particularly, is feeling the shortage severely, for much of her native wood was used during the war, and a great deal has been cut since for new houses and repairs to bombed buildings. Strict economy is exercised and everything possible is done to prevent the premature destruction of timber, either from decay or from the depredations of insects.

Each year many hundreds of enquiries about the protection of wood from decay are received by the Forest Products Research Laboratory of the Department of Scientific and Industrial Research, in Princes Risborough, Southern England. The Laboratory carries out a great deal of research work on problems connected with timber, and this year the D.S.I.R. is sponsoring a two-month autumn Exhibition at the Building Centre, Conduit Street, London, showing chiefly the measures taken to combat dry-rot in building woods.

In favourable circumstances timber, of course, does not decay, and some kinds of wood last indefinitely in any conditions. But the common soft woods used in building deteriorate if they are exposed to persistent camp, and there is always danger of dry-rot setting in whenever the timber in a building becomes moist.

OWN WATER SUPPLY

Due to requisitioning, evacuation, and the general upheaval caused by the war, many buildings in the United Kingdom were unoccupied for long periods and many damaged in air raids. Consequently damp penetrated through the walls, roofs, floors and dry-rot had time to gain a foothold and spread. This dry-rot is a fungus which once established, is hard to eradicate. True, it depends upon moisture for its sustenance. But it carries its own water supplies by means of conducting strands, and so is able to invade the dryer parts of a building. It may even pass through considerable thicknesses of brick or stone. All these things the exhibition clearly illustrates.

It shows pure cultures in test-tubes of some of the fungi most commonly found in Britain which cause rotting in timber, and also photographs of fungal growths. Specimens of wood attacked by fungi are also on view. There is a board from a bathroom floor infected with dry-rot, and a piece of a joist from a cellar similarly affected. There are also examples of wood attacked by the less virulent Cellar Fungus, *Coniophora Cerebella*.

HOW THE TROUBLE DEVELOPS

Photographs illustrate the most likely places in which dry-rot may occur, and still more interesting are exhibits tracing the successive stages in the development of the trouble. These begin with a superficial growth of fungus, white at first, then acquiring lilac and yellow tints, which leads to the wood cracking across the grain and breaking up into rectangular-shaped pieces. After this the fruiting bodies appear, shaped like pancakes or thick brackets, having a crinkled surface covered with rusty red dust. This dust is composed of myriads of microscopic spores only 1/3,000ths of an inch long. Later tiny root-like strands develop and these act as the water-pipes for the invading fungi.

Further exhibits show the efficacy of different wood preservatives against fungi. There are samples of wood treated with coal tar creosote, or with water-soluble or oil-soluble preservatives, and, in specimen flasks, small blocks of wood are shown which have been exposed to the attacks of cultivated fungi. While the untreated blocks bear vigorous growths of fungi, those which have been painted with preservatives are unaffected. The necessity for various precautions in building, such as the provision of damp-proof courses, thorough ventilation, and the use of properly seasoned timber, is stressed.

In many ways, the exhibition shows that care and treatment of building timber is akin to practical medical science. Thus, the ideal is to keep timber healthy. If, however, trouble

has set in, it is necessary to diagnose the malady and to distinguish between the depredations of dry-rot and that due to insects, since the treatment is quite different. Examples are, therefore, on view of damage caused by the furniture beetle, which favours old woodwork, the death-watch beetle, which is often found in old oak structural timber, and the Lyctus powder-post beetle, which is a menace to new woodwork. The exhibition shows how damage from insects may be recognized by the narrow tunnels bored by the larvæ, the round exit holes made by the mature beetles emerging to mate and by the small piles of wood dust.

After the full extent of the damage has been ascertained, all the infected wood must be cut away and burned, and all plaster stripped off which contains any fungus strands. Then the adjoining brickwork must be thoroughly cleaned down and sterilized with a blow-lamp and some antiseptic solution, the source of dampness removed and proper ventilation ensured around the woodwork.

Such exhibitions serve to make every one more conscious of the dangers which may threaten their homes. It would be an impossible task for the authorities in any country to inspect every house. In Britain such steps as these help occupiers to take an interest in the matter, to know what signs to look for and how to reduce damage to a minimum.

ILO News Service, International Labour Office, Geneva

RISE IN FARM OUTPUT IN ASIA NEEDED TO INCREASE EARNINGS, ILO DECLARES

Geneva (*ILO News Service*).—If farm wages and cultivator's earnings are to be improved in Asia, a rise in the level of Agricultural productivity is a "fundamental necessity" the International Labour Office said in a report published on 28–11–1949.

The report dealt mainly with the problem of raising the level of farm wages and the earnings of primary producers. It said in this connection that efforts to increase productivity would have to come "through a general readjustment in the use of the factors of production—by changes in methods of production, an increase in capital equipment, and reallocation of resources".

To achieve better utilization of the available land area and thus attain higher levels of production, employment and remuneration, the survey said, "programmes for the reorganization of farming should be examined".

This examination, it urged, should take special account of "the possibilities of cooperative and collective methods of production and the consolidation and amalgamation of holdings into more economic units".

The report is one of six which have been prepared to serve as a basis for the discussion of the International Labour Organization's Asian Regional Conference to be held at Nuwara Eliya, Ceylon, January 16 to 28.

In a foreword, it is explained that the report's purpose is to review "the points to be considered in a survey of agricultural wages and incomes of primary producers, with a view to wage regulation and introduction of measures to increase these incomes".

It contains chapters dealing with the economic background, land tenure and its effects on labour, the labour market, levels of agricultural wages, payment of wages, wage regulation and means of raising the level of remuneration in agriculture, and a chapter of conclusion.

To increase agricultural production, the study declared, the level of farm techniques must be raised by the provision of facilities for general and technical education and vocational guidance. It also suggested the establishment of research and experimental farms, the provision of incentive goods and equipment, the granting to tenants of the possibility of land purchase, and the provision of better facilities for marketing, grading and storing agricultural produce.

The report pointed out that in Asia the agricultural labour supply greatly exceeds demand. A considerable part of the labour force, it said, is unemployed or at least under-employed, "while the growth of the rural population has outdistanced the expansion of the cultivated area, with the result that there is a constant tendency towards a decrease of regular employment opportunities and a decline in earnings per individual farm worker".

The real problem of the landless labourer at the moment, it said, "is perhaps not so much what he is to earn, but rather whether he is to earn at all".

An increased demand for labour at the present technical level, the survey suggested, could be encouraged by increasing the share of income of certain categories of agriculturists, especially tenants and share croppers, in order to enable them to hire labour at a reasonable wage or to acquire some land.

In view of the special conditions prevailing in Asia, the report concluded, "some kind of state intervention is desirable" to achieve wage regulation in agriculture.

This view was advanced, it said, "because high rural birth rates and lack of opportunities for alternative employment in rural areas tend to create a buyer's market in respect of labour, so that agricultural wage rates compare unfavourably with those in other occupations". The Report argued also that the raising of wages through regulation may compel management to relinquish inefficient and wasteful methods of production.

EXTRACTS

THE GREAT WESTERN LAND GRAB

(Extract from Reader's Digest for November 1947)

Kindly communicated by Sri E. K. Kotwal, Conservator of Forests, Central Circle, Bombay Province

"Vast areas of the range country reaching west of the Great Plains to the escarpments of the Rockies have been overstocked and overgrazed. Where lush grasses once grew belly-high to a horse, relentless cropping by too many mouths has so skinned the land that it supports only half the live-stock it used to feed. Moreover, the close-cropped grass can no longer hold the soil in place when the rains come. Top soil washes into the mountain streams which fed the great rivers of the West, loading them with silt which is slowly choking reservoirs and irrigation systems in many states".

"In 1934 Congress passed the Taylor Grazing Act, to prevent over-grazing and soil deterioration". This law set up the Department of the Interior's Grazing Service to police the public lands, in which stockmen have bargain-price grazing rights. Most of the western stockmen approved. But not the big ranchers. While loudly urging that the public lands be "returned to the West", they have quietly and successfully undermined the Taylor Act.

It was easy. The Cow Block simply helped slash appropriations for policing the stockmen on the public lands. Congress cut the grazing field service budget from £1,070,360 to £373,000.

This meant that there could be only one office in each state to regulate 145,000,000 acres of range lands used by 29,000-odd ranchers. It meant that of 250-odd range examiners and graziers (inspectors) only 30-odd remained to patrol and police. And this added up to no federal inspection and control, since surviving personnel would have its hands full with *paper work*. In actual practice the Taylor Grazing Act had been repealed".

"The critical area that controls the arid West's water resources is the watershed region which lies chiefly in the forested uplands of Colorado and Wyoming—much of it within the 80,000,000 acres of grazing lands administered and protected by the Forest Service of the Department of Agriculture. Now, with the scalp of the Department of Interior's Grazing Service tied to their belts, the big stockmen are out to get these Forest Service lands. More than half of this area is badly depleted already, but efforts to cut down the numbers of cattle and sheep that graze there have plunged the Forest Service into a battle for its life".

"Meanwhile the stripped earth continues to wash away into the West's rivers. I stood in a gentle rain near the Continental Divide above Boulder, Colo., and watched a segment of the process which threatens the life of a whole region. A mountain stream which once ran clear and sparkling was now soil-choked. 'Too thick to drink and too thin to plow', a forest ranger put it. The Colorado, the Rio Grande and other great river systems are depositing millions of tons of top-soil from the range lands in the mammoth reservoirs which help nourish the semi-arid west. The Elephant Butte Dam, built to guarantee water to New Mexico 'forever', is already so choked with silt deposited by the Rio Grande that the state is alarmed over its water supply. The 2,000,000 citizens of Los Angeles rely on Colorado River water, impounded at Leak Mead behind Hoover Dam in Arizona. Los Angeles spent £240,000,000 to tap the water (and power) of Lake Mead, and the federal government spent about £165,000,000 more. But. inexorably, day after day, the Colorado deposits some 14,000 cart-loads of silt on the floor of Lake Mead, gradually filling it in".

A forest ranger commented bitterly : "Congress is spending billions for concrete dams to store water, but it won't spend pennies for the millions of little dams we protect—the blades of grass nature designed to save the land and water".

The lesson of the choking reservoirs, of the eroding grass lands and increasing floods is plain. A unified government command is needed in the fight against the forces of soil destruction".

DDT A STORY OF ERRORS

(Extract from World Crops)

The story of DDT is an excellent example of how not to publicise a new agricultural material or method. As one of the first technical secrets of the war to be released, it was swamped with an inflated number of headlines and radio talks from the announcement of its birth. No commercial organization could have given DDT the publicity that Anglo-American officialdom gave it towards the close of the war; the insect world was conquered unconditionally in printer's ink and in the short waves and the long. Any child beginning a promising career in such a fashion is bound to cease being a prodigy and become a suspected delinquent instead.

Let us first list the metaphorical flies in the DDT ointment. First was the fear that it would kill the bees and stop pollination, but this has been the eternal question asked about all new insecticides. DDT survived this traditional difficulty fairly well; its toxicity to bees, if care was taken in times of spraying, was no greater that than of other established orchard sprays. Far more serious was the assistance DDT gave to the red spider by killing off those insects which had formerly kept red spider populations down. This was a major disability that had to emerge with practice; and it cannot be denied to-day that new insecticides are being developed to deal with the increased attacks of red spider which have resulted from the use of DDT.

Simultaneously came the scare about DDT accumulations in milk and meat, and there is no doubt that when cattle feed upon DDT—treated fodder the fat-soluble DDT in spray residues builds up in the fats of the animals. Milk can contain enough DDT to be toxic to flies, and the concentration of DDT in a product such as butter can become dangerously high from the point of view of feeding to children.

Next it was found that house-flies could develop resistance to DDT. Flies which managed to resist its effects stayed alive to breed so that by a counter-action of the natural selection type, an increasing number of flies which inherited resistance was found in areas where DDT had been heavily used. There is evidence that this has, indeed, been taking place in the United States since 1947. The question agriculturists must ask is whether other insect pests can in time do the same.

The next recent blow, however, is the charge in America that the mysterious disease attributed to 'virus X' is actually no more and no less than DDT poisoning. Medical authorities have accused DDT manufacturers of marketing DDT products for general use without first compiling full information about their toxicity.

We do not believe ourselves that DDT is a burst bubble. Too much was expected of it far too quickly, and now each instance of trouble or failure recoils upon DDT with added force. Had DDT been developed slowly and quietly these difficulties would have occurred on a smaller scale and they would, in any case, have been looked upon in their proper light, as the normal growing pains of any new product or idea. Such growing pains are either overcome or, if not, are faced as reasonable limitations of the product. Fools rush in where angels fear to tread, and the case of DDT publicists certainly did enormous harm by rushing in where scientists and expert agriculturists would have been content to tread slowly and cautiously.

FOREST NEWS*

Overfellings in European Forests.—The fellings in west—European forests amounted to 140 per cent of the total increment, as per figures given by the Forestry Commission of the United Nations. Last year 128 million cb. m. (4,520 million c. ft.) of timber was felled (excluding firewood) which exceeded the increment by 35 million cb. m. (1,260 million c. ft.). The production of firewood and wood-pulp timber exceeded the European demand, while the production on mine-props, railway-sleepers and coniferous sawn-timber was 20 to 30 per cent short of the demand. The wood-deficit of Europe is at present being covered by import from other continents. The commission expects Europe to become self-sufficient

* Extracted from *Zeitschrift für Weltforstwirtschaft.*

within a reasonable time. Excluding Russian forest areas, Europe has only about 0·34 hectare (0·84 acre) forest area per head of population, i.e., less than any other portion of the globe. In North America the forest areas hitherto not opened up are now being tackled, and in Africa and South America a similar tendency is evident.

MEDITERRANEAN COUNTRIES

The Forest Problem in the Mediterranean Countries.—The International Forester of the mediterranean countries has been revived by Robert Hickel under the new name "Silva Mediterranea". Its activity is being continued under the FAO in its new form. It has on its programme the solution of economic and technical problems connected with the improvement of forest management. Forest problems have to be dealt with in a different way in different countries. For example densely populated Italy cannot be compared to another land which has abundant natural resources but a meagre population. Consequently it is not possible to draw up a uniform (similar) programme for all the mediterranean countries.

The setting up of a forest programme on the basis of evaluating the forest according to the proportion of forest-bearing area of a country to its total area and area under agriculture or with the so-called relative forest area per head of the population is not of much use in countries which vary widely from one another in their physical and economic structure. Moreover, in mediterranean countries, forest area can be to a certain extent correctly estimated when one takes also into account the sources of timber found outside forest areas proper, namely, in the extensive orchards and in cultivated lands. The extent of the forest area to be aimed at can only be determined when the local peculiarities are correctly determined. In silviculture one cannot go according to the same fixed rules for every country. The utilization of the underwood is therefore not a poor or backward method of silviculture. Moreover the rapid development of the technique for the uses of timber has caused all proposals for a long production cycle (rotation) to be discarded. Unlike in Central Europe, in mediterranean countries scientific, experimental and technical ground-work of forestry have to be placed on a wider basis, encompassing several countries, if world-silviculture has to be develop in consonance with the natural laws of the forest. This fact applies pointedly to the mediterranean countries, where the forest is in a less advantageous situation with respect to its physical surroundings, and man has always attacked and upset the balance of nature. The same holds good as regards forest protection, measures against irrational grazing, forest fires and diseases. The technique against these injuries is astonishingly similar in various countries. Inspite of this, if co-operative effort had been closer and better organized many a mistake would have been avoided and greater progress achived.

For example the existence of the *Castane vesca* (Gaertn) (Chestnut tree), one of the most important tree species of the mediterranean area, is jeapordized by the appearance of the disease *Andothia parasitica*. The war against this disease and the encouragement of the growth of this tree could have been carried on still more effectively than what is being done in Italy to-day, if all the countries interested in this affair had worked in co-operation. The improvement of forests of the mediterranean countries with regard to the methods of natural regeneration and reaping of the forest crop deserves, similarly, to be taken up at inter-States' level. To serve this purpose, efforts should be made to establish an international union of the forest research institutes of all mediterranean countries.

A good portion of Itlay's requirements of construction timber, and one which compensates for the inadequate yield of her forests, is met by the Poplars which grow over a large portion of the plains of the river Po. According to the Italian forest statistics of 1946–47 the forests produced 3·7 million cb. m. (130$\frac{2}{3}$ million c. ft.) of timber and 11·4 million cb. m. (402$\frac{2}{5}$ million c. ft.) of firewood. The trees in the Po river plains produced during the same period 700,000 cb. m. (2·47 million c. ft.) of timber. Adding to this the production of timber from other non-forest areas, this figure goes up to 1 million cb. m. (35$\frac{1}{3}$ million c. ft.), which means that trees standing in agricultural areas produce timber equivalent to about a third of the yield of timber from the Italian forests. Tree growth from other than forest areas supply about 12 million cb. m. (423$\frac{4}{5}$ million c. ft.) of firewood, while the yield from the forests is about 11·4 million cb. m. (402$\frac{2}{5}$ million cb. ft.) or a little less. In the whole hf

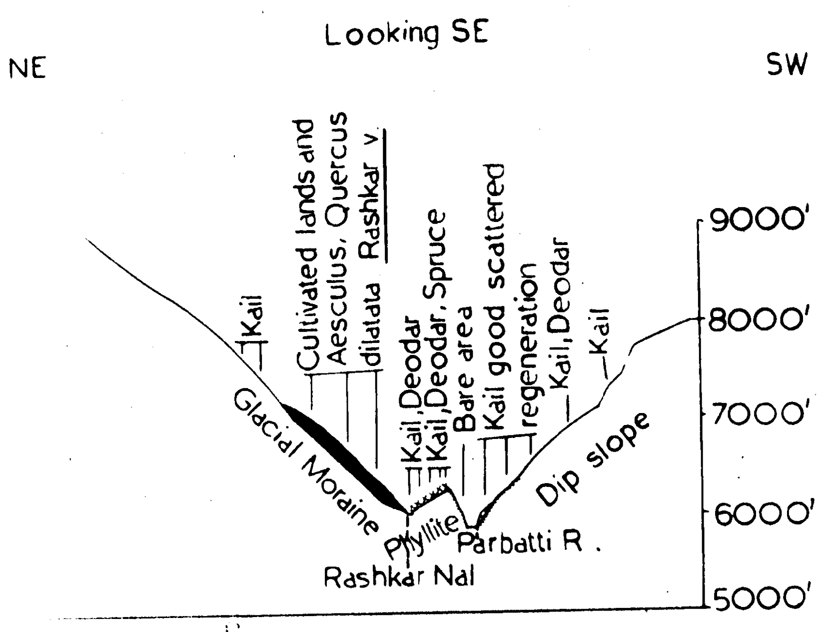
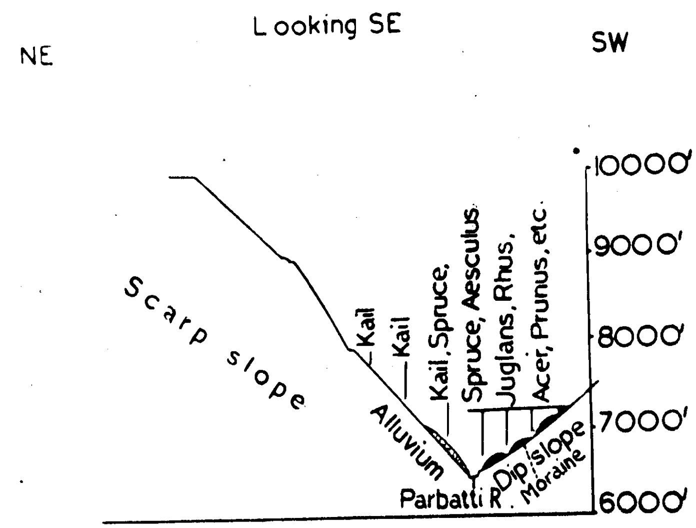


FIG. 14. Relation between tree communities and geology in the Parbatti Valley near the Rashkar Village.



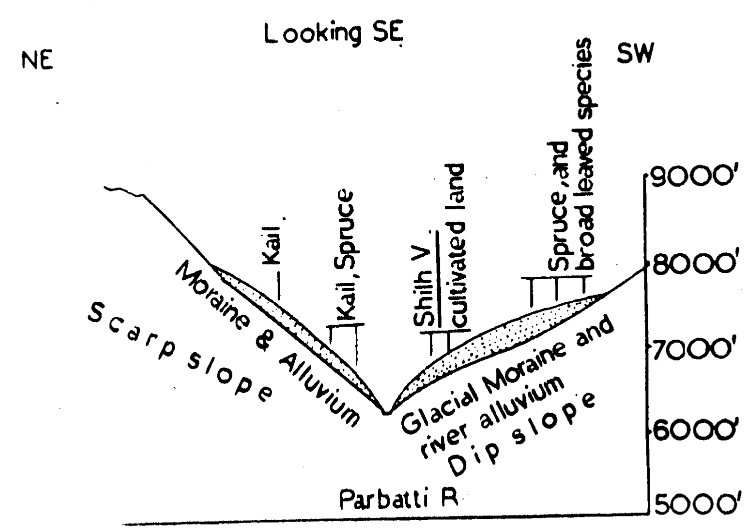


FIG. 15.—Relation between tree vegetation and geology in the Parbatti Valley above Village of Shilh.

FIG. 16.—Relation between tree communities and geological features in the Parbatti Valley above Kukri.

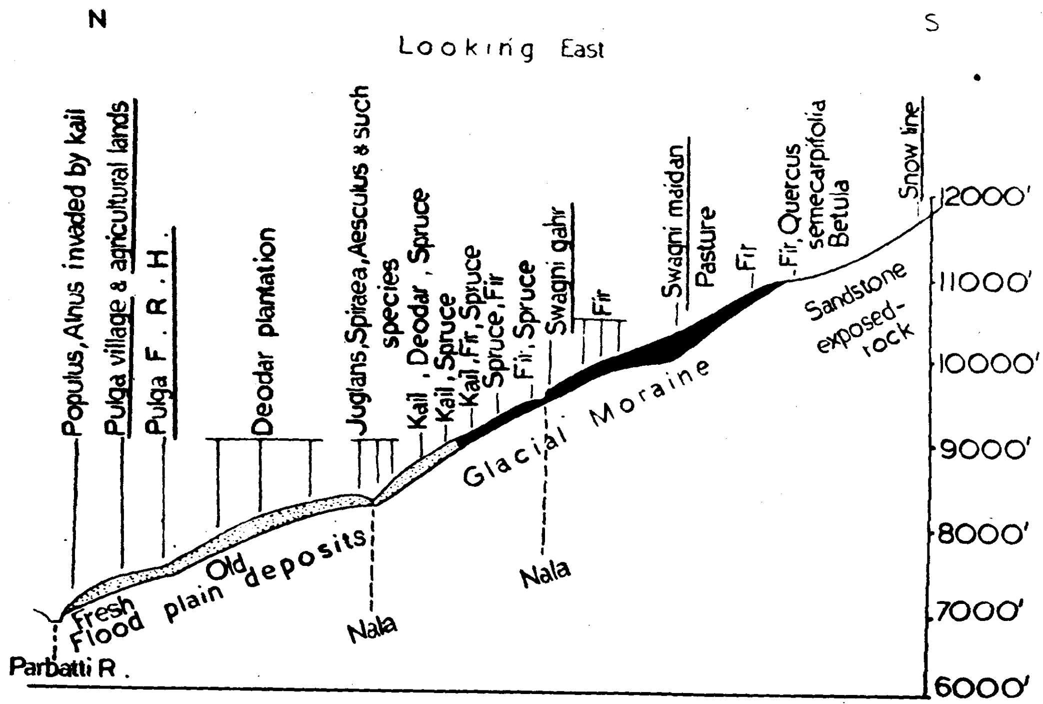


FIG. 17.—Relation between tree communities and surface deposits at Pulga.

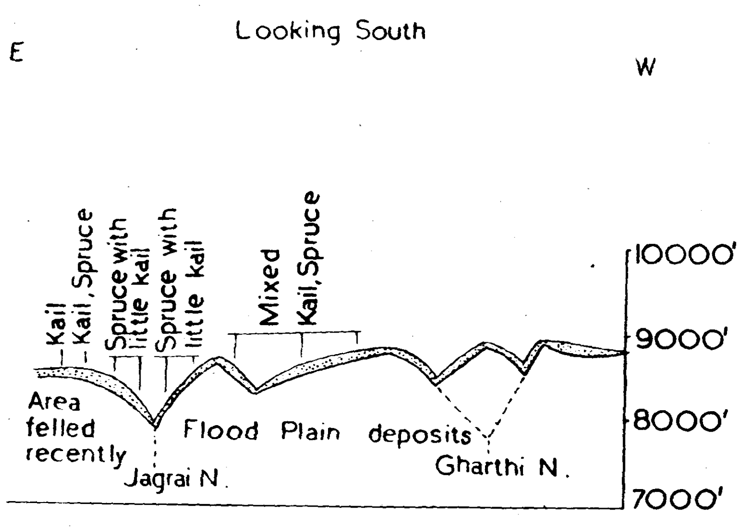


FIG. 18.—Tree communities on food plain deposits above Pulga.

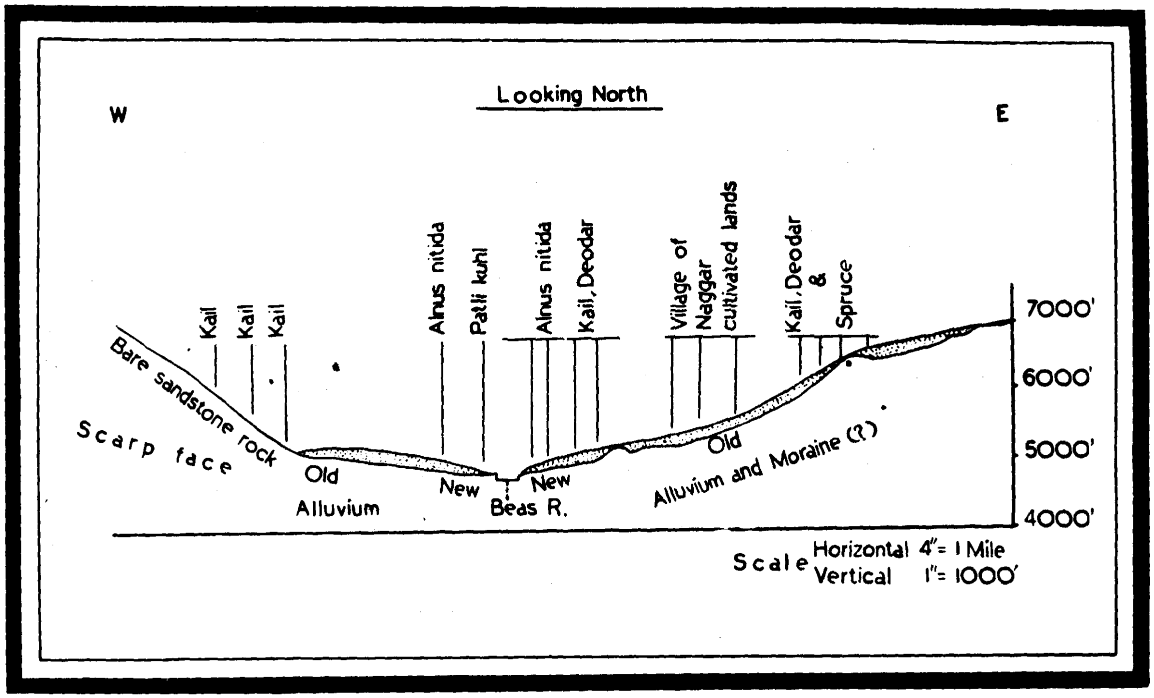


FIG. 19.—Relation between Forest communities and geological features in the Beas Valley near Naggar. Note the U-Shaped, wide nature of the Valley and presence of glacial moraines.

central Italy, especially in the southern portion, trees in wind-proof belts of cultivated fields from an important source of timber supply for the near future, and this timber can be brought easier and quicker into circulation than forest timber, owing to accessibility.

In Southern Italy the orchards can supply considerable quantities of timber, especially of firewood. For example, Apulien has practically no forest, but the tableland of Foggia, in which there are absolutely no trees, differs strongly from the former zone in being rich in Olive trees, which stretch from Bari to Lecce, where especially the Olives but also Almond trees and Vine-props provide ample timber for the population. The estimate of timber production in the mediterranean countries could therefore be considered complete only when it does not confine itself merely to timber production from forest areas.

Denmark

MEETING OF THE DANISH FOREST UNION ON 20TH MAY 1948 AT ODENSE

The following matters were discussed in the meeting :—

(1) The importing of 40 rotary fraise-machines was decided upon, to be set apart for distribution mainly among private forest owners.

(2) Connection was established with American Offices in order to revive the import of seed of Douglas fir.

(3) The leaflet "Forestry in Denmark" and the quality-table have appeared in their new editions with 600 and 300 copies respectively.

(4) A special committee was set up for fighting the fungus attack of Trametes.

(5) The starting of a forest labourer's school was proposed. The estimate of cost was put down at 180,000 crowns. The lodging, journey and teaching will be free and loss of wages will be compensated.

Growth of Birch under Oak.—The development of birch under an oak crop, both while the oak overwood has been retained or removed was investigated in sample plots of ½ hectare area. All measurements indicated that with the removal of oak overwood, birch improves in its volume production and the quality-class goes up by one step. From the management view point it is of no advantage to fell and replace the birch with a coniferous species after removing the overwood of oak. Still less advantageous it is to fell the birch and replace it by another broadleaved species.

YIELD OF DANISH FORESTS IN 1946–47

Out of the total area of Government forests which covers 75,838 hectares (187,396 acres), 78% i.e., 58,657 hectares (144,941 acres) are stocked with forest growth. This forest area represents 17 per cent of the total land area of Denmark. The extraction of 443,885 cb. m. (15,676,065 c. ft.) of wood represents an excess felling of 21 per cent over the normal (prescribed) yield. While, on an average 7·7 cb. m. (271·9 c. ft.) of wood per hectare was felled, in heath-covered areas the actual yield was only 4·5 cb. m. (158·9 c. ft.) per hectare. The quantity of building timber felled was 250,000 cb. m. (8,828,900 c. ft.) against the prescribed yield of 210,000 cb. m. (7,416,276 c. ft.). By extracting the stumps 50,000 cb. m. (1,783,438 c. ft.) of wood was obtained. In addition to the above the State Forest areas supplied 43,000 tons of peat fit for burning. An area of 1,590 hectares (3,929 acres) of forest was regenerated artificially with seedlings of 7 million conifers and 10 million broadleaved species.

The total gross income stood at 14,190,066 crowns against the expenditure of 13,500,309 crowns.

Canada

The export of wood, paper and products of wood between January and June 1949 amounted in value to 408,186,000 Canadian dollars, representing a decrease of 45,148,000 Canadian dollars against 1948.

(Unasylva).

Philippines

For the official year ending 15th April 1949, timber and log production in Philippines reached the record figure of 2·25 million cb. m. (79,460,138 cb. ft.) which exceeds the quantity cut in 1938 by a narrow margin. Most of the output was used for internal consumption. The value of exports is estimated at 2 million American dollars.

(Unasylva).

K. K.

REVIEW

"FOREST INFLUENCES" by JOSEPH KITTREDGE

Published by Messrs. McGraw-Hill Book Company, 1948

"Forest Influences" forms a comprehensive treatise on an analysis of the water relations of the Forest. The aim of the book, as set out by the author in the introduction, is to evaluate the influences of forest cover on climate, water and soil and to correlate the present knowledge of these effects with their application to the successful management of forest from the standpoint of the conservation of water, and the control of floods and erosion.

The view-point in "Influences"—the effects of forest on habitat—represents the inverse orientation to studies, such as Silviculture and Ecology where the emphasis is on the effects of the habitat on the vegetation. The author's method is essentially a mathematical analysis of the physiological activities of plants into purely physical phenomena thus permitting their expression in quantitative form. Considerable quantitative data, hitherto widely diffused, has been successfully collected for this purpose.

In the chapter on "Methods" Prof. Kittredge points out the inadequacy of laboratory experiments alone in the determination of influences and the necessity for biometric analysis to determine the applicability under field conditions of these results.

The vegetational factors treated are measures of foliage, composition of the forest, density of stands, size and age, site quality, cutting and logging, fire, natural succession and forest litter. These factors are evaluated with respect to their integrated effect on the factors of locality and the ultimate correlation of these factors with the water relations of the forests.

Separate chapters are devoted to the influences of forest cover on each of the factors of habitat—solar radiation and light, air temperature, wind, atmospheric moisture, precipitation, interception and stream flow, fog drip, evaporation and condensation, snow, soil evaporation, soil temperature, soil moisture and transpiration.

An interesting chapter on "Litter and Forest Floor" is included.

The litter, duff and humus layers which constitute the forest floor are distinguished according to their position and degree of decomposition, "primarily oxidation of the organic matter and consequent progressive mineralization of the forest floor materials". Experimental data are adduced to show the consequent progressive increase in the percentage content of Nitrogen, Calcium, Potassium and Phosphorus from the surface litter to the humus. The author has given some very interesting results regarding annual accumulation of litter, etc., e.g., the total accumulation of forest litter varies from 3·5 to less than 0·5 metric tons per acre in moderately well stocked stands and is higher on better sites, but shows no significant difference with different species and types. The heaviest annual fall in well stocked stands occurs about the age of culmination of the current annual increment and is less at older and at younger ages. The ratio of total forest floor to annual accumulation in temperate climates varies commonly between 3 and 15, but under tropical conditions of rapid decomposition the ratio would be one to one or even smaller.

The author further points out to the influences of litter and forest floor on soil productivity, i.e., addition of forest floor to soils of poor sites increases forest growth and removal of forest floor or its excessive accumulation as peat or raw humus deteriorates site quality and decreases growth.

The beneficial effects of fire in the quick release of nutrients from litter to the soil is most evident under conditions of rapid decomposition as in tropics. Where decomposition is slow, fire consumes most of the nutrients in the upper layers and its effect would be detrimental.

The question of "how many years after a forest is planted on bare eroding land or abandoned fields will the effect of its protective cover become noticeable", is considered, inconclusively, however, in view of the inadequate data.

The latter part of the book is devoted to chapters on the influence of forests on run off and stream flow, Floods, Erosion, Control of Erosion and Vegetation for Erosion Control, and as would be expected provides considerable overlap. Grass cover is as effective as forest in minimizing surface run off. Vegetational

cover lowers flood crests and causes prolonged flow in low water periods. Further by reducing debris and sediment in water, vegetational cover tends to minimize flood damage. The chief causes of accelerated erosion set out are disturbance or destruction of the cover by fire, overgrazing, land clearing, improper cultivation, abandonment, construction work, logging, hydraulic mining, smelter fumes and changing stream channels. Erosion may be controlled by decreasing or diverting surface run off or a combination of the two in one or more of 3 principal ways :—

(i) Retention in less erodible areas by check dams, interception ditches, debris basins, etc.

(ii) Conveyance in artificial channels or protecting eroding banks by stream control—spurs, revetments, mattressing, etc.

(iii) Covering eroding areas with brush, litter and vegetation. This would be preceded by necessary preparatory measures such as closure to grazing, grading banks and heads to the natural angle of repose, etc. Species used for afforestation should be pioneers in natural succession with rapid juvenile growth, large fibrous root system, resistance to damage by insects, diseases and grazing animals and capable of growing on adverse sites.

The final chapter on Watershed Management and Protection Forest, rounds off the argument, the author has outlined throughout the book, and points out how best the beneficial effects of influences can be harnessed to the advantage of man.

The general get up of the book is of a high standard. A valuable summary is given at the end of each chapter. "Forest Influences" would prove stimulating to its readers, and presages the scientific outlook which must needs govern forestry to-morrow.

JASWANT SINGH,
Assistant Lecturer, Indian Forest College.

APPRECIATION

HARRY PERCEIVAL SMITH, B.A. (Cantab.), B.A. (Oxon), C.I.E., Indian Forest Service (1921–1946)

H. P. Smith, known to his friends as "Jungley" Smith, or more often merely as H. P. (also short for "horse power") left the marks of zeal and efficiency on all his work. He was a true forester, first and last ; he took so naturally and so readily to forest life, even under the adverse conditions of physical discomforts, isolation and unhealthiness that were such inevitable features of life in the Assam (or the Andamans) forests. He brought an excess of energy, enthusiasm and ability to bear on anything that he undertook ; and all that tended to delay progress made him so impatient. Assam owes a great deal to Smith for most of the recent advances in the management and administration of her forests.

Young Smith interrupted his academic career to serve in World War I. The long spell of soldiering from 1914 to 1919 (when he attained the rank of 'Major') did not, however, affect his scholastic abilities and he graduated subsequently from both Cambridge and Oxford Universities.

Smith joined the Indian Forest Service in 1921, being one of the first batch of post-war recruits, and posted to Assam. He spent the early years of his service in the sal forests of Goalpara, one of the heaviest divisional charges in the country. Great credit should go to Smith for his work in the construction of the Goalpara Forest Tramway, over 40 miles of narrow guage track in difficult *tarai* and *bhabar* country. The successful working of this tramway has changed and enlarged the entire scope for working these valuable sal forests. His interest in things mechanical led to his deputation, for special training, with Messrs. Spear and Jackson's Works, Ltd., Sheffield. This was followed by a term of useful service under the Government of India in the Andamans forests, where he employed his natural talents fully towards improved forest exploitation and timber engineering.

On return to Assam, he had a further spell of divisional work, this time in the evergreen forests of Cachar. Such diverse experience (in sal mixed deciduous and evergreen forests, in both valleys of Assam and outside the province) stood him in good stead when he took over administrative duties from 1935, first as Personal Assistant to the Conservator and later as Conservator of Forests, Assam. Though it had been recognized earlier that concentrated (artificial) regeneration was inevitable in the evergreen forests of Assam, it was Smith who was responsible for systematizing procedure for large-scale plantation work,—with the result, that Assam is probably the only province in India where every Forest Working Plan has a distinct "Part III—Plantation Scheme". While work (in the sal forests) on natural regeneration received a great impetus initially from the foresight and direction of Milroy, further progress was possible mainly because of the personal encouragement and energetic supervision it received from Smith.

Smith went on deputation again in 1942, to the Government of India, this time to help in the organization of India's timber supplies for World War II. Almost immediately he brought a new outlook to bear on the work in the Timber Directorate. His energetic, rapid and confident disposal of every problem was indeed an eye opener to many there. He would later repeat with pride how he used to go out of his way to pass a good story round just to relieve the 'heavy' atmosphere. Armed with experience of supply work at the Centre, Smith returned to Assam (as the head of its Forest Department) towards the end of 1943 and plunged into active direction of supplies of material essential for camp construction, etc., in the various war zones in the Province and beyond. It may be claimed that but for these prompt and effective supplies, the course of the

war in malarious Assam might even have taken a different turn. His invaluable services to the State earned for him due recognition in 1945, when he was awarded the C.I.E. In May 1946, Smith proceeded on leave preparatory to retirement. Smith has left Assam, but his services to Assam will ever remain.

To the last day of his career, his work was characterized by great vigour and speed. For him (even when he was past 50 and could command every reasonable comfort), to leave headquarters at 3 A.M. in midwinter, surprise the first Beat Officer on the way by waking him up before dawn, stop at a succession of places to check progress of work, listen to difficulties or issue instructions and reach a halting place for the night having driven two or three hundred miles, was merely a routine days' work. A senior official of Assam often remarked that Smith compressed three days work in one and did so every day. Another compared him to an excessively high powered vehicle—in fact referred to him as a Rolls Royce engine inside a Baby Austin body.

Mr. and Mrs. Smith were popular assets to the social life of the stations he was posted to. 'Jungley' and Jill Smith were both well known for their utter lack of formality and their generous hospitality. In these social circles, they also had a considerable reputation for talent in amateur dramatics. To young officers their genuine kindness was a tonic against all difficulties. Their *comradarie* and affection towards the staff were as complete, as Smith's personal enthusiasm and energy at work, were infectious.

We wish Mr. and Mrs. H. P. Smith good health and all happiness in a long life of retired ease, well earned.

C. A. R. B.

CONVOCATION OF THE INDIAN FOREST COLLEGE AND THE INDIAN FOREST RANGER COLLEGE DEHRA DUN 1950

The joint convocation of the above two colleges, for the formal passing out of successful candidates during the 1948–50 courses took place before a very large and distinguished gathering, in the convocation hall of the Forest Research Institute on the 2nd of April 1950 at 3-30 p.m. The Honourable Sardar Vallabhbhai Patel was to have presided on the occasion, but was prevented from so doing by other pressing duties. The function was presided over by Shri M. D. Chaturvedi, I.F.S., Inspector-General of Forests for India.

Messages received from Shri Rajendra Prasad, President of the Republic of India, the Honourable Shri Jairamdas Daulatram (Minister for Agriculture), the Honourable Maulana Abul Kalam Azad (Minister for Education), and Shri K. L. Panjabi, I.C.S. (Secretary to the Government of India, Ministry of Agriculture) were read.

MESSAGES

I

From SHRI RAJENDRA PRASAD, President of India—from the Military Secretary to the President

I am desired by Shri Rajendra Prasad, President of India, to thank the President, Forest Research Institute and Colleges, Dehra Dun for his kind invitation to the Convocation of the Forest Colleges to be held on Sunday the 2nd April 1950, and to say that while the President is very appreciative of his kind thought which prompted him to send the invitation, he regrets his inability to attend.

The President, however, sends his best wishes on the occasion.

II

From the HONOURABLE SHRI JAIRAMDAS DAULATRAM—Minister for Agriculture

Much as I would have liked to be present in person at the Annual Convocation of the Forest Colleges, Dehra Dun, it is with great regret that I have to deny myself the pleasure because of my pre-occupation with parliamentary duties. I take this opportunity of congratulating all of you who have successfully gone through the forestry courses and are now entering the threshold of your profession. I am not unaware of how arduous and exacting your life in forests must need be, but you will always have the satisfaction of performing a duty of vital importance towards the conservation of our national forest resources and their utilization to meet the ever increasing demands of industry and above all the daily needs of the common man. I earnestly hope you will not spare yourself in fulfilling the tasks assigned to you, in doing your best to safeguard and enrich our national heritage and *in maintaining the best traditions* of the Forest Services of Free India which you are entering to-day.

III

From the HONOURABLE MAULANA ABDUL KALAM AZAD—Minister for Education

Maulana Abul Kalam Azad thanks the President, Forest Research Institute and Colleges for his kind invitation to the Convocation of the Forest Colleges on Sunday, April 2nd 1950 at 3-30 p.m. but regrets his inability to attend owing to previous engagement.

IV

From SHRI K. L. PANJABI, I.C.S.—Secretary to the Government of India, Ministry of Agriculture

I must confess to a feeling of keen disappointment at my inability to come to Dehra Dun to attend the Convocation. I had very much looked forward to being able to be present on this important occasion. But last minute engagements have prevented me from doing so. I wish to convey my sincere felicitations to the students receiving their diplomas and certificates to-day, at the termination of their strenuous courses, which I have no doubt, will stand them in good stead in performing their duties in the management of a proud heritage committed to their care. I need hardly emphasize the need for the new entrants to the Forest Services of India to live up to the high standards of service and integrity set by their worthy predecessors. I wish them all the best of luck in their careers.

Shri C. R. Ranganathan, I.F.S., President, Forest Research Institute and Colleges opened the proceedings with a short address in the following words :—

"Mr. Chaturvedi, Ladies and Gentlemen :

On behalf of the Forest Research Institute and Colleges, I have great pleasure in welcoming you all to this Convocation. It is a matter of great regret and disappointment to us that the Hon'ble Sardar Vallabhbhai Patel has been prevented by affairs of State from being with us to-day. He has been good enough to send the text of the address which he had intended to deliver. It will be read by Shri Chaturvedi, Inspector-General of Forests, who has kindly consented to deputise for Sardar Patel on this occasion. It is fitting that, in the absence of our illustrious Deputy Prime Minister, the first batch of students to complete their full two year course after the assumption of independence by India should receive their diplomas and certificates from the first Indian Inspector-General of Forests.

"As is well known, the Government of India controls all professional forest education, whether for gazetted officers or rangers, through the Forest Research Institute and Colleges and its new auxiliary the Madras Forest College. This is an arrangement which has served us well in the past. In the altered conditions brought about by the Constitution of the Republic of India, the need for the continuance of this arrangment and its potential benefits are in my judgment greater than ever before. Forestry is a state subject in the new Constitution. But forestry is a subject of more than local importance, in both its protective and productive aspects. It is obviously desirable, if not indeed essential, that a common co-ordinated forest policy should be followed in all the States of the Union. Several of the instruments which enabled a concerted forest policy to be evolved and adopted in the past have disappeared, but one of the most powerful of them still remains, namely, centrally directed professional training of all the forest officers of India. I hope it will continue to remain.

"In my speech at the last Convocation, I referred to the proposal to affiliate the forestry courses at Dehra Dun to Delhi University. I regret to say that we have not made much progress in this matter. Certain difficulties came to light on further consideration of the proposal. These are being dealt with and a decision will be taken by the Government of India in the near future.

"Last year it seemed that we were in a phase of active expansion of the Forestry Services in India. But the outlook now does not seem nearly so bright. The need for a great extension and intensification of forestry operations and enterprises is no less acute to-day, but the deterioration in the financial situation and the compelling need for economy have forced a slowing down in the post-war expansion schemes of the States. This has reflected itself in a reduced demand for seats in both the officer and ranger courses for the next year. It is to be hoped that this contraction of development schemes is only a passing phase.

"I do not wish to anticipate what the Director of Forest Education may have to say in the report which he will presently read on the work of the Forest Colleges at Dehra Dun during the last year. But before I conclude I must refer to certain changes of staff which have occurred during the year and certain

others which are impending. Shri C. A. R. Bhadran who served as Director of Forest Education for nearly two years left us in November 1949 to revert to his province. He had served in the Forest Research Institute and Colleges for 4½ years, as Principal of the Indian Forest College, as Personal Assistant to the President, and as Publicity and Liaison Officer, to which last post were later added the duties of Director of Forest Education. In whatever capacity he served, Shri Bhadran brought to his task a tireless industry, great organizing capacity and much *savoir faire*. Both he and his wife contributed much to the social life of this colony. We were sorry to have to bid good-bye to them.

"Shri Bhadran's place has been taken by Shri K. L. Aggarwal, a senior officer of the Indian Forest Service from Punjab. The combined post of Director of Forest Education and Publicity and Liaison Officer is no sinecure, but there is no doubt that Shri Aggarwal is fully equal to it.

"The period of Shri P. N. Suri, a retired officer of the Punjab Forest Service, has terminated. Shri Suri has been serving in the Indian Forest College since 1946 as a Lecturer. With his versatile knowledge of forestry and long experience of forest conditions, he combined physical vigour and unsparing activity in the field which were truly amazing in an officer of his age. It is regrettable that he has to leave us.

"Shri S. Ramaswamy, Instructor in the Indian Forest Ranger College, proceeded on leave for four months in December 1948 before reverting to his permanent post in the Minor Forest Products Section. In his place we have secured the services of Shri I. N. Sewal, a senior Forest Officer of Uttar Pradesh. Shri Ramaswamy rendered valuable services as Botany Instructor in both the Forest Colleges and we are sorry to lose him to the Institute.

"Shri Arjan Singh and Shri Bhagwan Das, Instructors at the Indian Forest Ranger College, are leaving us at once, the former to take up a special post in Himachal Pradesh and the latter to return to his province, Punjab. Our thanks are due to them for the good work they have done during their tenure in the College. Shri Arjan Singh has been a very useful and popular member of the collegiate staff for five years and we are parting from him with much regret.

"I will now ask the Director of Forest Education to present his report".

Shri K. L. Aggarwal, I.F.S., Director of Forest Education then presented a report on the working of the 1948–50 courses of instructions in both the colleges. The following is a summary of his report.

Mr. Chaturvedi, Ladies and Gentlemen :

I beg leave to present the report on the working of the 1948–50 Courses of instruction in forestry, of which the students are passing out to-day.

1948–50 Course.– There are two parallel courses, one at the Indian Forest College for Gazetted Officers and the other at the Indian Forest Ranger College for Forest Rangers. In addition to candidates from the various States of India, for whom these colleges are primarily meant, candidates have also been accepted from Nepal, Ceylon, Persia and other adjacent countries from time to time. Ninety-nine students have successfully completed these courses this year, 37 as Gazetted Officers and 62 as Forest Rangers. Out of the 37 Gazetted Officers, 9 belong to U.P., 5 to Bihar, 4 to West Bengal, 3 to North-East Frontier Agency, 3 to Assam, 3 to Orissa, 1 to Himachal Pradesh, 3 to Madhya Bharat, 2 to Rajasthan, 3 to Ceylon and 1 to Nepal. Of the 62 Rangers, 5 belong to Assam Tribal Areas, 4 to Punjab, 11 to U.P., 9 to Assam, 5 to West Bengal, 12 to Bihar, 4 to Himachal Pradesh, 5 to Madhya Bharat, 1 to Bilaspur, 2 to Bhopal, 1 to Rajasthan, 1 to Manipur, 1 to Tripura and 2 to Nepal.

Courses of Study.– In addition to all aspects of commercial and state forestry including Forest Engineering, Survey, Botany, Plant Ecology, Mycology, Forest Pathology and Entomology Instructions were also given in Soil Conservation, planned land use, roadside avenues, canal bank plantations and farm-forestry for which the services of the forest officer will be required to an increasing degree to enable him to contribute his share to the welfare and uplift of our predominantly agricultural population. Besides the regular instructions given by the college staff the students had the further advantage of receiving instructions on such specialized subjects as Mycology, Forest Pathology, Forest Zoology, Forest Utilization, Soil Science and Wood Technology from the Specialist Officers of the Forest

Research Institute. To all these officers, I take this opportunity to express our gratitude.

Practical instruction in field engineering was also given by the staff of the Royal Indian Engineers at Roorkee. The students were given a course of lectures on 'First Aid to the Injured' under the ægis of the Dehra Dun District Centre of the St. John's Ambulance Association.

As it was felt that the students were overworked both during tours and lecture terms a revised programme has now been drawn up. The lecture terms at head quarters have been increased and touring has been curtailed. Lectures have now been so arranged as to enable all regular college work to be completed in the forenoons before lunch hour. This will enable the students to devote more time to their studies, recreation and social contacts.

It has not been possible so far to adopt a three years' course recommended by the Gwyer Committee for Gazetted officers on account of the necessity immediately after the war of meeting the increasing requirements of provinces and states for trained forest personnel. At the same time, it was felt, that the adoption of three years' course would raise the expenses by 50%. In view of the acute financial stringency prevailing in the country, it will, therefore, not be possible to increase the training period for sometime to come.

Tours.—Officers classes toured in the Forests of the Punjab, Uttar Pradesh, Bengal, Bombay and Madras. Timber and other forest industries were also studied specially at Bareilly, Calcutta, Siliguri, Bombay, Dandeli, Calicut and Mysore. Touring for Ranger students was less extensive and it was restricted to U.P., Madhya Pradesh, Himachal Pradesh and the Punjab. Forest industries at Bareilly, Balharshah and Clutterbuckganj were also studied.

As the concession allowed to students proceeding on educational tours has not been restored by Railways, the students have to avail themselves of accommodation only in the lowest class even on long journeys in the interest of economy. Concession to students during vacations for travelling to and from their homes, however, still exists. Travelling difficulties are aggravated as the railway administration is unable to provide accommodation on fast trains, thereby causing unnecessary waste of time. This matter has been referred again to the Railway Board and it is hoped that satisfactory arrangements would be made.

The Railway authorities, particularly the Station Master and Staff at Dehra Dun, the Divisional Superintendent, Moradabad and the Chief Transportation Superintendent, East Indian Railway, Calcutta deserve special thanks for the help rendered during tours. Thanks are also due to the various Forest Officers in whose divisions tours were undertaken and to the Food and Supplies Ministry U.P., and the T.R.O., Dehra Dun for enabling the students to draw rations in advance during tours.

Affiliation into Delhi University.—The question of affiliation of the Forest Colleges to the Delhi University is still under consideration.

Examiners.—Several Officers of the Forest Research Institute and of the different states who helped the college authorities in conducting examinations of students, have also to be thanked for their trouble.

The Madras Forest College.—The Madras Forest College at Coimbatore was taken over by the Central Government in July 1948. The intention then was to train students from the northern region at Dehra Dun and from the southern at Coimbatore.

Accordingly one officer class and two Ranger classes were conducted at Coimbatore from 1st July 1949. Due to financial stringency, however, fewer candidates have been deputed by the various States for the 1950–52 course. There will therefore be only one Ranger class at Coimbatore from July 1, this year.

Accommodation.—The Ranger college was run at two places : two classes in the old original premises in Dehra Dun and two in the new college buildings at New Forest. The plan for an additional building remains in abeyance in the interest of economy.

Hostel and Mess.—It is obligatory for the students to have their residence in the hostels. Common Messes are run and their management is undertaken by elected students under the guidance of Instructors. Adequate standard of living was maintained inspite of the high prices. A few rooms were converted into living rooms to accommodate the students of the Officers' course. Hostel accommodation for Ranger students at New Forest is inadequate and it appears that the present tem-

porary accommodation will have to be used for sometime more owing to financial stringency.

Sport, Games and General Health.—Physical training and games are prescribed as part of the curriculla in both the colleges. The general health of the classes was good throughout the year, except for two cases of injury and one of dysentry in the Senior Rangers and 4 cases of injury and one of pyrexia among junior rangers. Of these, one senior ranger student from Sirmur who remained in Hospital for 67 days on account of a fracture in his leg, sustained while playing football, missed the Himachal Pradesh tour in May/June 1949, and will undertake this tour in May/June 1950, before he is awarded the certificate. On the whole, however, there was general improvement in the health of the students after joining the college.

The Ranger College Dehra Dun Section annexed the Volleyball cup, while the Football cup and Hockey trophy were won by the staff of the F.R.I. The Indian Forest College won the cricket cup and the Team-Championship prize in the Annual Athletic Sports. The individual championship was divided between Shri Koelmeyer of the Indian Forest College and Shri Satya Bhushan of the F.R.I. Shri Hari Singh of 1948–50 Ranger's Course from U.P., won the 8-mile Marathon Race.

The traditional high standard of discipline, decorum and good conduct was maintained. Except for one or two lapses, the students observed discipline fully. One student Shri M. R. Trivedi from Rewa in the 1948–50 Ranger Course, had to be removed from the college for gross breach of discipline and moral turpitude. It is hoped that this will have a salutary effect on the general discipline in the college.

Conclusion.—The Ranger College has built for itself a great reputation in the last 70 years of its useful existence. Though the Indian Forest College is a new Institution, it has already built up for itself an equally good reputation.

The Director of Forest Education in conclusion exhorted the outgoing students to cultivate a high sense of duty and responsibility and of total integrity and to devote themselves whole heartedly to the service of the country in their respective states.

Shri V. P. Mathur, Principal, Indian Forest College, announced the results of the Indian Forest College, and Sardar G. S. Lamba announced the results of the Indian Forest Ranger College. Medals, prizes and certificates were presented by Shri M. D. Chaturvedi to the successful candidates. A list of the successful students and recipients of the prizes and medals is appended :

INDIAN FOREST COLLEGE

FINAL RESULTS OF THE 1948–50 COURSE

Sl. No.	Name	Province or State
In order of merit		
HONOURS.—		
1	K. O. KOELMEYER ..	Ceylon.
2	A. B. RUDRA ..	West Bengal.
PASS.—		
3	K. M. TIWARI ..	U.P.
4	S. B. PALIT ..	West Bengal.
5	S. RAJKHOWA ..	Assam.
6	KUBER NATH ..	U.P.
7	D. N. MISRA ..	U.P.
8	K. N. SINHA ..	Bihar.
9	W. G. WEERARATNA	Ceylon.
10	V. B. SINGH ..	U.P.
11	R. N. KAPOOR ..	Bihar.
12	G. K. BORA ..	Rajasthan.
13	S. S. SRIVASTAVA ..	U.P.
14	P. N. GUPTA ..	U.P.
15	R. C. SAXENA ..	Madhyabharat.
16	W. B. BATHEW ..	Assam (N.E.F.).
17	R. PRASAD ..	Bihar.
18	P. MOHAPATRA ..	Orrisa.
19	M. D. UPADHYAY ..	U.P.
20	SATYA VRAT ..	Himachal.
21	S. N. BANERJEE ..	Bihar.
22	L. C. DAS ..	Assam.
23	W. R. H. PERARA ..	Ceylon.
24	B. N. SINHA ..	Bihar.
25	S. N. MISRA ..	West Bengal.
26	E. J. B. RANA ..	Nepal.
27	B. K. PURI ..	Rajasthan.
28	I. P. GARG ..	U.P.
29	R. C. PATNAIK ..	Orissa.
30	M. N. ASTHANA ..	U.P.
31	S. N. BHONSALE ..	Madhyabharat.
32	S. BASU ..	West Bengal.
33	LALTHANZAMA ..	Assam (N.E.F.).
34	D. P. BORA ..	Assam (N.E.F.).
35	P. C. GOGOI ..	Assam.
36	B. L. DAS ..	Orissa.
37	L. R. JANGLEY ..	Madhyabharat.

INDIAN FOREST COLLEGE

LIST OF PRIZE WINNERS—1948–50 COURSE

1. Hill Memorial Prize for Silviculture

S. B. PALIT .. West Bengal.

2. College Prize for Management

A. B. RUDRA .. West Bengal.

3. College Prize for Botany

K. O. KOELMEYER .. Ceylon.

4. College Prize for Surveying and Engineering

A. B. RUDRA .. West Bengal.

5. College Prize for the best all round student and the most practical Forester

K. O. KOELMEYER .. Ceylon.

6. Principal's Prize for the best student who has not got any other Prize

K. M. TIWARI .. U.P.

7. Special Prize for the student showing outstanding Organizing Capacity

K. M. TIWARI .. U.P.

Mr. A. B. Rudra who stands first amongst the Indian Forest Service candidates is being recommended to share in the award of the Currie Scholarship with the student who stands first in the parallel course run at Coimbatore. The scholarship is paid from a trust fund in England to the student of the Indian Forest Service who obtains the highest marks for the Course and is equivalent to about £35.

INDIAN FOREST RANGER COLLEGE

EXAMINATION RESULTS (FINAL)— 1948-50 RANGER COURSE

Sl. No. in order of merit	Name of student	Province or State
	HONOURS	
1	Avtar Singh Bhinder ..	Punjab.
	HIGHER STANDARD	
2	Ram Narain ..	U.P.
3	Vishnu Pal Singh ..	U.P.
4	Maha Deo Joshi ..	Indore.
5	Hari Singh ..	U.P.
6	Mahi Pal Singh ..	Punjab.
7	Girja Dhar Singh	U.P.
8	V. M. Palsule ..	Gwalior.
9	S. K. Prasad ..	Bihar.
10	Debabrata Chatterjee ..	Bihar.
11	D. S. Pande ..	U.P.
12	S. P. Chowdhury ..	U.P.
13	J. N. Shrivastava	U.P.
14	R. N. Ghosh ..	Bihar.
15	Inamul Hussain ..	Assam.
16	N. C. Bhattacharjee ..	Tripura.
17	A. K. Poddar ..	Bengal.
18	Rasik Kumar Thakre ..	Dhar.
19	Deep Singh ..	Jhabua.
20	Raj Narain Lal ..	U.P.
21	K. S. Pandeya ..	U.P.
22	Kaleshwar Sinha ..	Bihar.
	R. R. Upadhyaya	U.P.
24	Ran Bahadur Rai	Assam.
25	Saran Singh Bhalla ..	Punjab.
26	Satish Chandra Agarwal ..	U.P.
27	J. C. Chakravorty	Bengal.
28	R. P. Mishra ..	Gwalior.
29	Nirod Ranjan Das	W. Bengal.
30	Prafulla Kumar Datta ..	W. Bengal.
31	Jageshwar Gopal Shrivastava ..	Bhopal.
32	Sarad Chandra ..	Mandi.
33	G. C. Deka ..	Assam Tribal Areas.
34	B. K. Pathak ..	Assam.
35	Ram Deo Thakur	Bihar.
36	R. N. Ray ..	Assam.
37	Ram Ashish Singh	Bihar.
38	Tarun Chandra Phukon ..	Assam Tribal Areas.
39	Sumer Chand ..	Sirmur.

Sl. No. in order of merit	Name of student	Province or State
40	P. C. Barah ..	Assam Tribal Areas.
41	S. S. Arif Ali ..	Bihar.
42	Atma Nand Vijh ..	Punjab.
43	Shyam Sundar Bhagat ..	Bihar.
44	Patan Devi Sahaya ..	Bihar.
45	Parsuram Mishra ..	Bihar.
46	B. S. Kishtawaria ..	Chamba.
47	Pal Lal Sanga ..	Assam.
48	Pushpeswar Barah	Assam Tribal Areas.
49	G. S. Kothari ..	Mewar.
50	Ng. Shamu Singh	Manipur.
51	Mohit Narayan Singh ..	Bihar.
	P. S. Chandail ..	Bilaspur.
53	S. M. Wasi ..	Bhopal.
54	Ghanshyam Chowdhuri ..	Assam.
55	S. Adhikari ..	Bengal.
56	Khiranath Gogai ..	Assam.
57	Sanson Momin ..	Assam.
58	Sudhir Jang Thapa	Nepal.
59	Devi Prasad Bailoong ..	Assam.
60	Madan Mohan Laha ..	Bihar.
	LOWER STANDARD	
61	Padmeshwar Saikia ..	Assam Tribal Areas.
62	Murat Singh ..	Bashahr.

INDIAN FOREST RANGER COLLEGE

PRIZES AWARDED TO THE 1948–50 COURSE

1. Honours Gold Medal
(To the best student gaining most marks in all subjects throughout the course)

A. S. Bhindar .. .. Punjab.

2. Fernandez Gold Medal for Utilization

D. Chatterjee .. .. Bihar.

3. Silver Medal for Forestry

A. S. Bhindar .. .. Punjab.

4. Silver Medal for Engineering

Inamul Hussain .. Assam.

5. Silver Medal for Botany

A. S. Bhindar .. .. Punjab.

6. McDonnel Silver Medal
(To the best student from Punjab or Kashmir)

A. S. Bhindar .. .. Punjab.

7. William Prothro Thomas Prize
(To the best practical forester)

Mahipal Singh .. .. Punjab.

8. "Indian Forester" Prize
(To the best student who has received no other prize)

Vishnu Pal Singh .. U.P.

(This will be in the shape of free subscription to *Indian Forester* for a period of two years).

9. Director's Prize
(To the second best student who has received no other prize)

M. D. Joshi .. .. Indore.

10. Hazarika Memorial Prize
(To the student gaining highest marks in tour examinations)

Ram Narain .. .. U.P.

In the unavoidable absence of the Deputy Prime Minister, his address was read by Shri M. D. Chaturvedi, Inspector-General of Forests.

The full text of the address is as follows :—

"Shri Ranganathan and friends,

"I must apologize to you all for my inability to address your convocation personally, as I had been looking forward to. When one is caught in the whirlpool of overriding official engagements, the fundamental rights of freedom of movement and of personal liberty have perforce to be suspended and, unlike the ordinary citizen, the victim has no forum to which he can have recourse for redress. I am sure, therefore, that all of you will sympathize with me in the circumstances which have compelled me to deny myself the pleasure of meeting you and sharing with you a few thoughts and ideas. I need hardly tell you that if you suffer from a sense of disappointment, mine has deep regret mixed with it.

NO STRANGER

"The Forest Research Institute of Dehra Dun is no stranger to me. I have already had glimpses of its work. Its sylvan setting, its picturesque walks, its ideal surroundings, have all attracted my attention during my prolonged stay in Dehra Dun both last year and the year previous. I have also closely seen the rich collection of its museum and have acquainted myself, through some study and contact, with the work that is being turned out within its premises. Yours, friends, is an old Institution, almost as old as myself. Its history shows how from small and humble beginnings 72 years ago, it has changed its character and widened its scope until to-day when it is the nursery of all that is best and useful in forest service and a laboratory from which are turned out valuable research products in a vital field of national enterprise.

"It is no facile or facetious compliment that I am paying Forestry when I refer to it in the terms I have done. Forests, as natural resources, are the most wronged by the hands of men who should appreciate their utility better. In the struggle for existence or in competition with nature, human beings are apt to follow the path of least resistance and taking a narrow short-term view of their needs and the resources available for their fulfilment, lay their hands on the nearest available resource without any forethought of their replacement for future requirements. The history of denudation of the forest resources of this country is replete with instances of cruel exploitation of this vital national wealth and criminal waste of capital placed in our hands by a bountiful Nature. Planned exploitation of such resources, based on the principle of preservation and replacement, is a feature of comparatively recent date. Obviously, we cannot make up the leeway of centuries, but we can by judicious planning and lay-out still husband the resources that are available and create wealth which, in course of time, may achieve that balance between afforestation and clearance which is the hall-mark of scientific planning.

FORESTS SATISFY NEEDS

"After all, forests satisfy our basic needs with a universality which might well be the envy of those who believe in bringing wealth within the reach of all. The humble dweller of village huts, the rich dweller of luxurious city buildings, the cook in his kitchen and the more fortunate possessor of a well-furnished drawing-room, all alike draw from the forests the means of satisfying what to each is an elementary and essential need. But how few have the attitude of reverence and consideration for the trees and plants that sacrifice themselves in the service of mankind? Worship of trees is still an old tribal or village custom. We ourselves in our cosy chairs touch wood to invoke blessings or to ward off the evil-eye. In one case there is the closeness to a readily available aid for existence ; in the other, there is a recognition of value forced by habit rather than by conviction. But in both there is the element of sanctity which needs greater realization and genuine appreciation in every-day life.

"Applying these thoughts to realities and hard facts of statistics I find that the total forest area of this country covers 171,000 sq. miles which gives a percentage of 22·6 to the total land area. If we consider the requirements of our vast population and the need for softening the rigours of its climate and combine

this with a study of the distribution of the area under forests and the comparatively poor state of our communications, we shall at once be struck with the deficiency of the resources that are available. At a conservative estimate, in order to have a balance between open and covered area, we must add at least one third more to our area under forest.

"We have also to consider another broad fact which has recently been claiming increasing attention. Do not the failure of monsoon on the East Coast during the last three years, the fitfulness of monsoon in North Gujerat and Saurashtra and the encroachment which the desert of Rajputana is making on the Gangetic plain suggest the need for so ordering our forest belts as to create conditions more helpful to averting what might eventually be a certain disaster to life and happiness of millions? The part which forests play in moderating the rigours of climate and meeting the growing menace of desert or the trespass of the rivers and mountain streams on fertile soil can hardly be over-estimated.

"The existence of mounds and ridges where, only some years ago, there were green pastures or smiling crop-lands, the surrender which cultivation has been making to barrenness, and the presence of bare rocks where years ago the sylvan goddess stood in all its splendour, should convince us of the heavy drain which is slowly but surely being made on our priceless treasures on which depends our ability to feed our growing population.

NEED OF AFFORESTATION

"If we are to survive this growing struggle for existence, this process of denudation of our wealth has got to be stopped and we have to plan a nation-wide scheme of afforestation which would provide against the dangers to which I have referred above. To neglect this essential field of nation-building activity would be a national disservice and a failure to discharge a vital duty of administration and citizenship.

"I realize that simultaneously a system of scientific exploitation of our rich timber resources must go on. The total revenue from forests in former Provinces alone amounted to about 10½ crores and the total out-turn of timber and fire-wood amounted to 1/3 and 5 million tons, respectively. Moreover, forests, while saving us from the ravages of flood and famine, can themselves become a menace to cultivation. Scientific felling of forest areas combined with fresh growth, which would at least make up for the loss of forest wealth involved, must be the aim of a sound working plan. Forests also provide indispensable raw material for important industries, both big and small.

"The proper utilization of forest wealth must, therefore, be an important part of our national policy, if we have to succeed in increasing national prosperity, but here also our watch-word should be that we create more than we destroy and turn all our uncultivable area capable of being brought under the plantation into lands yielding either valuable forest wealth or performing the useful function of sentinels against the forces of elements, water, weather and sands.

SCIENTIFIC STUDY

"Friends, I am afraid I have now wearied you with a few thoughts which struck me as being germane to the pleasant duty of addressing this gathering of accomplished and budding experts in forestry. There has been a constant rivalry between the expert and the layman ever since the dawn of history. It was an irate layman belonging to the bewigged variety who divided witnesses into three categories 'liars, damned lairs and experts'. I shall not be so judicial for a politician has to be judicious and shall at once recognize the value which experts have in every department of human activity. I also realize my own limitations; the expert must begin where the layman ends and, if necessary, help the layman to carry on. Even as a professional I was and remained only a lawyer; may be for some Magistrates and Judges I was a 'damned lawyer', but unlike my expert friends I stopped there. I hope, therefore, you will bear with me for a while, if I place before you the layman's demands on the expert.

"The common man must be scientific if he has to make a success in life. The virtues of precision, of logic, of a careful understanding of causation and effect, and of scientific imagination, criticism and analysis must be cultivated in his own humble way by an

average citizen. Without the elements of these virtues, the average man cannot fulfil adequately the role, which he must, in the exacting field of democracy.

VIRTUES OF EXPERT

"The role of the expert in any form of Government, except that of experts, is also equally, if not more, exacting. Knowledge shines best when scholarship is combined with humility. With the limits of knowledge undefined and undefinable, an expert is no more than a child gathering pebbles by the sea shore. The expert or the technician has also to be tolerant of the faults and shortcomings of persons less equipped than himself. It is no use his carrying on a store-house of knowledge with him, if he cannot make those who are going to utilize it, understand its potentialities and utility. He must, therefore, treat others not with condescension but with consideration and with a view to converting and not merely controverting.

"The instruments of experts are the men of the 'humbler lay' and they cannot, therefore, afford to quarrel with their own instruments. Similarly, it is the common man and their problems that must afford an expert opportunities for testing and putting to practical use his technical knowledge and ability. My appeal to you, who are now entering the threshold of their career in public service, is to regard your service as a field of duty and not merely an opportunity for a career, to treat the common man with sympathy, understanding and consideration, to make him realize his shortcomings and put faith in your knowledge and ability and then to place at his service unreservedly and unstintedly all that is best in yourself. It is only then and in this spirit that the common will extend to you that confidence and trust without which your own true mission in life cannot be a success that it deserves to be.

"Also please remember that the resources of the State are limited ; you own it to the country to achieve the maximum at minimum cost. It is good to have sometimes your heads above in the clouds but never lose the grip on Mother Earth. Trailing clouds may lend you their glory but they will be driven away by the mildest breeze whereas even in a blast, the firm ground below will give you foothold. After all stability is essential for success in life and without it even a genius cannot make good in this world.

"Friends, I now come to the last and most pleasant duty which I would have been more than delighted to perform personally to-day. It is to congratulate all those who are the proud recipients of diplomas after a successful completion of their courses. They have had the satisfaction of their labours being rewarded. I only hope and pray that their labours in the service of the country will be equally successfully rewarded. I also congratulate your President and members of the staff on the successful closing of one more year in the life of this great institution. May this Research Institute grow in stature, in service, and in usefulness as it completes its spans from year to year !

"I shall now close with one more a word of apology for my failure to fulfil this engagement and a word of gratitude for the kindness with which you have tolerated this lapse of time".

"Jai Hind".

Shri M. D. Chaturvedi, the Inspector-General of Forests, then addressed the meeting, in the following words :—

"Mr. Ranganathan, fellow-workers, Ladies and Gentlemen,

"It is indeed very much to be regretted that the Honourable Sardar Vallabhbhai Patel who was to address this Convocation has been prevented by the matters of the State from gracing this occasion. While voicing our keen sense of disappointment I would like our appreciation of his address to be conveyed to him. Our thanks are also due to the President of the Republic, the Honourable Shri Jairamdas Daulatram, Shri K. L. Panjabi and others who have sent us messages of goodwill.

2. I would also like to take this opportunity to express our feelings of gratefulness to our other guests who have come here in response to our invitation.

3. Might I crave your indulgence, Sir, to the few remarks I have to offer by way of advice to

the out-going officers after their stay with us for a period of 2 years ?

4. It is customary on such occasions for speakers to indulge in didactic platitudes and inflict upon the victims of this initiation ceremony, advice on such matters as the inculcation of the sense of responsibility, duty to the State and to themselves, the need of sticking to the path of rectitude and reminding them of the opportunities which await them round the corner.

5. I do not propose to cover this familiar ground. Instead, I am permitting myself to strike rather an unusual note—a note of warning to prepare you for what to expect when you report yourself to duty in the forests.

6. Life in forests is so desparately lonely that for days on end, the only civilized face you see is your own. Stuck out at the back of beyond, you are completely cut from civilization. Cinemas, clubs and other opportunities for social contacts are of course out of question. You are denied even such elementary amenities as post. Your newspaper, the only link you have with the outside world, reaches you 3 to 4 days late. If supplies run short, you resort to the ingenious device of going without them.

7. How well I remember having to wash my *dal* with soap to take off the smell of kerosene which was unwittingly knocked over it by a *sambhar* who had mysteriously found his way into the improvised kitchen. Needless to say, the *dal* when cooked smelt both of kerosene and soap.

8. Nor, have I forgotten the day when in my utter exaspiration I resigned my job. And, had it not been for the merciful intervention of a Senior Forest Officer, I would not have been here to recount my experiences.

9. I have painted a pretty dismal and gloomy picture, but not without purpose. I warn you the maddening solitude of your life will get you, unless you get at first. It is well to remember the well-worn adage "if you cannot get what you want, you must want what you get". The only way to get used to your weird environments is to fall in love with them. You must develop an all-absorbing interest in your surroundings. Be it botany or birds, butterflies or nests, photography or mycology you must develop a passion for your pursuits. It is because of this peculiar approach, this incessant urge, that Forest Officers in the past have distinguished themselves in fields so different as collection of beetles and study of birds' nests.

10. Among the various facets which Nature presents, there is none so breath-taking as the study of wild-life. Whether you shoot with a camera or a gun, it is immaterial. What matters is the earnestness you bring to bear on to your hobby. If it is a camera make a careful study of all its gadgets. You should know what exposure to give, what film to use. If you use a gun, learn all about its bores and ballistics. Few Forest Officers can answer the question why a 16-bore gun has a smaller bore than a 12-bore gun. You must clean your own weapon, track your game, learn to tie a *machan* and follow up your quarry. Study the fellow denizens of the forest at close quarters. Learn their ways, their habits and habitats, baits and traits.

11. There is nothing so exciting as matching your intelligence with that of a tiger, and nothing so sophisticating as a confession of defeat to the superior prowess of that noble beast—the tiger. With such meticulous care I used to study my tiger beats that I could predict correct to within a few minutes the appearance of Mr. Stripes. Running the beat for one of the Governor-Generals, I made the mistake of my life of trying to excel myself. I not only pointed out the exact point of time but also the spot where the tiger was to appear. I was in the beat myself and brought the tiger to His Excellency's gun. The tiger appeared tick on time, but at a spot about 25 yards to the left of the place I had indicated. You can imagine my bitter disappointment when I learnt from His Excellency that he never saw the tiger. Luckily, I was supported by His Excellency's daughter who interrupted her father's protestations by shouting from the adjoining *machan* 'Daddy you are blind—the tiger passed to your left'. Further enquiries revealed that His Excellency had taken me so much on trust that at the appointed time he had rivetted his rifle to the spot indicated by me, and had shut his right eye. The tiger escaped through this partial black out. A careful check up of the beat provided the clue to the unforgivable lapse on the part of the tiger. Some one had let fall a piece of white

paper in the way of the tiger. It was this wretched piece of paper which made the tiger choose the path which emerged about 25 yards away to the right.

12. During my recent tour in Orissa, I had the excruciating experience of making my acquaintance with many a Forest Officer who had never seen a tiger, much less shot one. Small surprise then, that answering an interpellation in the local parliament at Cuttack, the Hon'ble Minister-in-charge of Forests informed an unsuspecting House that a little over 50 women and children had been killed by man-eaters in Kalahandi during the previous 6 months or so. He went on to inform the House that the needful had been done. And, the needful consisted of calling the Police to apprehend the miscreants. I drew the attention of the Chief Minister to the ludicrousness of the situation. There is nothing so demoralizing as a Forest Officer looking on helplessly at man-eaters and cattle lifters ravaging the country-side. It will be a salutary rule if the State Governments insisted on an officer shooting his first tiger, before considering him for the charge of a division.

13. As an earnest of my desire to enthuse you in the study of wild-life, more particularly the tiger, I have brought for your mess a trophy which I hope will inspire you during your brief sojourn here. It will lend special piguancy to the tiger's head on the badge of your blazer and will help you to keep the tradition of sport alive in the Forest Service you are entering to-day. I wish you all good-luck and Godspeed in the life you are embarking upon".

The occasion was availed of for announcing the award of the Howard Medal for the year 1949 (for the best piece of independent research by a member of the non-gazetted technical staff of the Institute) to Shri Balwant Singh, Research Assistant, Entomology branch for his research work on "Immature stages of Indian Lepidoptera (8) Geomelridæ".

Shri M. D. Chaturvedi, then presented the Indian Forest College mess with the magnificent trophy, a tiger's head mounted on a shield.

The conference terminated with three cheers for the Inspector-General led by the Senior-most student of the Indian Forest College.

A SIMPLIFIED PLANIMETER

BY DR. K. KADAMBI
(*Assistant Silviculturist, Forest Research Institute, Dehra Dun*)

We are living in an age of increasingly complex mechanisms and so strongly linked therefore is our daily trend of thought with innovations and inventions of the more and more complex types that it does not occur to most of us that our minds could sometimes be directed with great advantage at simplifying some of our more complex and difficult-to-use and at the same time expensive scientific instruments ; yet, if one calmly ponders over and critically examines some of our professional instruments ways and means might suggest themselves for reducing some of them to absolute simplicity. One of the methods of tackling the problem of rendering the complex mechanical devises simpler is by studying the principle involved in their construction and trying to get up something which can approach the use of the same principle though a different channel. Sometimes one stumbles upon ridiculously simple devises, yet they may be devises capable of immense use.

Every student of engineering and forestry is conversant with the rather elaborately constructed "polar type" planimeter, but few care to bother about the principle on which it works. It is known, for instance, that a simple steel rod bent twice at right angles could be made to serve the same purpose as the "polar type" planimeter and yet have a degree of accuracy which may not transgress an error limit of 1 to 2 per cent, if properly constructed and carefully used. A photograph of one such instrument, the first of which was constructed about the beginning of the year 1940 in a remote forest camp known as Agumbe in Mysore state, illustrates this article. It so happened that one of the Ranger School students, who had been asked by the writer to practice planimetering, was moving one of the points of a double-bladed pen-knife, having its two blades half open, repeatedly along the edge of an irregular figure, when he accidentally noticed that the movement of the free blade of the pen-knife he was using described a uniform figure whose size varied directly with the size of the figure on which he was exercising. He came to the writer with his observation and on careful examination it was soon established that the size of the figure described by the movement of the free limb of the pen-knife bore a constant ratio to the size of the figure planimetered. It did not take long to work out this ratio and to arrive at the method of calculating the area of the figure planimetered. The pen-knife planimeter was soon replaced with a rod bent twice at right angles in the same plane and direction. On his return to head quarters and looking up some old German literature the writer found that this useful instrument was not anything absolutely new, being known since the closing years of the last century.

How to construct the simplified planimeter.—The simplified planimeter can be constructed from a steel rod of about $\frac{1}{4}$ inch thickness bent twice at right angles, as shown in the figure, with one of the ends sharpened into a tracing point and the other flattened out to form a knife-edge, the edge being in the same plane as the long axis of the rod.

The accuracy of the instrument is swayed by the following important points bearing on its construction and use.—

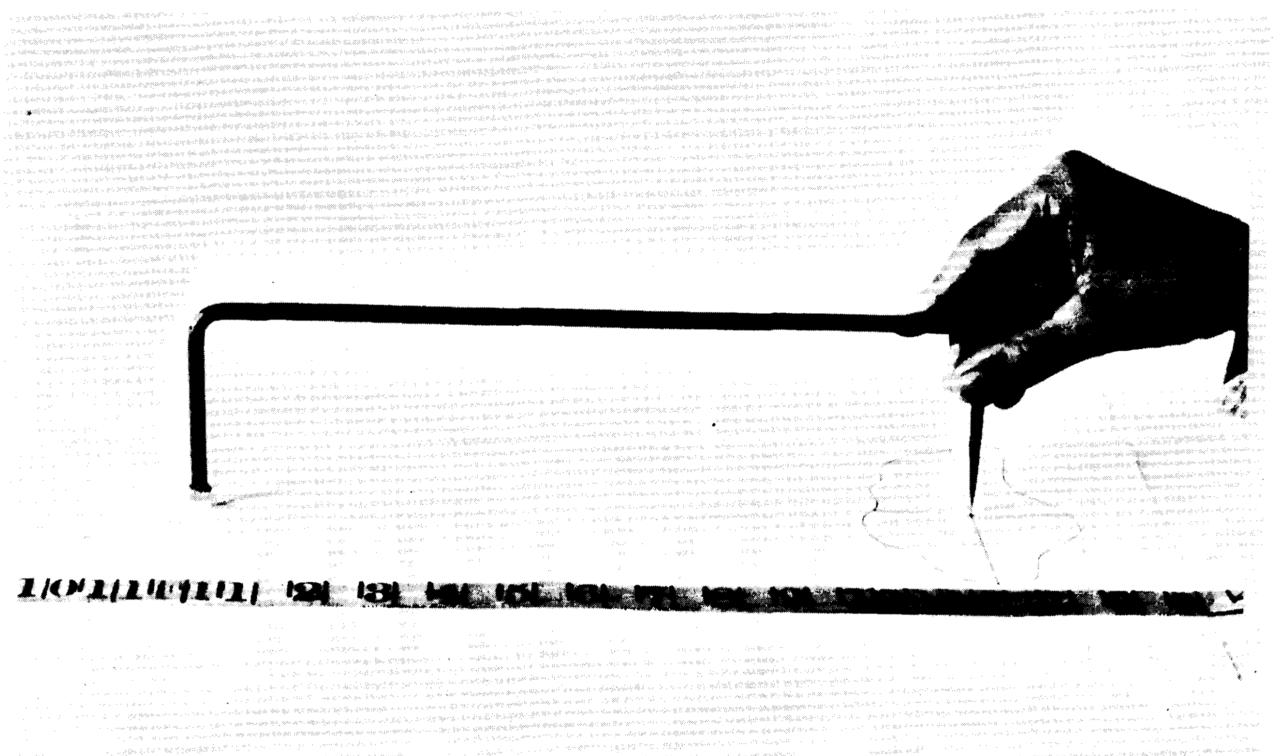
(i) The tracing point and knife-edge should lie in the same plane.

(ii) The distance separating the knife-edge and the tracing point should be accurately known.

(iii) The instrument should be held perfectly vertical during the tracing.

The knife-edge should be carefully tempered after it has been sharpened, while the tracing point should not be too sharp because it would then pierce the paper while in use. A convenient size for the instrument would be one with the bent arms 3 in. long each, the knife-edge and the tracer being 10 to 12 in. apart from each other.

How to use the planimeter.—The area of any figure traced by the simplified planimeter is obtained by multiplying the distance between



Simplified Planimeter.

the tracer and the knife-edge (which we may call 'L') which is a constant for each instrument, with the distance between the positions of the knife-edge at the commencement and end of the tracing. Locate approximately the centre of the figure to be planimetered (see figure) and place the tracer on the point of intersection of the two co-ordinates. Place the instrument parallel to one of the co-ordinates as far as possible. The knife-edge should also rest on the surface of a clean, preferably unglazed, piece of paper. Press the knife-edge lightly into the paper to leave a mark which we will call 'm'. Now trace along one of the co-ordinate lines to the line forming the boundary of the figure, then along the boundary line round it then back along the same co-ordinate line to the starting point. It will be seen that the knife-edge now occupies a separate place on the paper. Press the knife-edge slightly on the paper and it will leave a second mark on it which we will call 'n'. The area of the figure is now obtained by multiplying the distance between 'm' and 'n' by the distance between the tracer and the knife-edge of the planimeter (L). In practice it would be better to repeat the operation by tracing in the direction opposite to the first tracing round the figure. When this is done, the knife-edge should return from the point 'n' to the starting point 'm'. If the tracing has been very accurately accomplished the knife-edge will return exactly to 'm', but this is rarely the case in practice and there is always some change in the original and the subsequent positions of the knife-edge. We will call this new position of the knife-edge 'm′'. Now take the average of the two distances between n and m and n and m′, and multiply it by L to get the area of the planimetered figure.

In accuracy, the simplified planimeter compares favourably with the costly and more elaborate polar type planimeter with which most foresters are familiar. Ordinarily, if the precautions given above are taken quite accurate results can be obtained with the simplified planimeter. In their very first attempt some of the ranger students were able to work correct to a 2 per cent accuracy, while a few did even better. Rapid working, without bestowing much care on the details of tracing, gave consistently less than 2 per cent error on forest survey maps of the 4 in. to the mile scale. There are no serious sources of error in the simplified planimeter. The accurate measurement of the distance between m and n is of vital importance in the area calculation, and a flat steel scale graduated to one-fiftieth inch will work fairly satisfactorily.

The simplified planimeter should be able to serve practically all the ordinary needs as regards area determinations by foresters, engineers and surveyors. To our Working Plan Officers and their sometimes untrained staff this instrument will be of great help in their working plan fieldwork. It is easy to train even forest guards in the use of the instrument. The writer, who has worked with it during his long working plan career, wishes to commend this simple instrument to all professional foresters in India.

TAPER CURVES FOR ACACIA CATECHU (*KHAIR*)

BY S. K. SETH
(*Silviculturist, U.P.*)

This note is based on analyses of taper statistics for 500 trees collected in compartment No. 19, 28, 29, Bhinga Range, Bahraich division and 100 trees in Tarai and Bhabar Estates division.

The data have been analysed by Shri D. C. Pande, P.F.S., Assistant Silviculturist, United Provinces. The field measurements consisted of diameters or girths at stump-height corresponding to diameters or girths at breast-height. Since stump-height has not been defined nor measured, the weakness of the data is apparent. However, *khair* trees are very valuable and the stump is generally kept very low ; there is therefore no reason to postulate a big variation in the stump-heights and the calculations are based on the assumption that the stump diameters and girths correspond to a reasonably constant average stump-height.

After the data had been classified, the weighted averages were plotted and smooth empirical curves were drawn. The trend of the plotted points did not indicate a linear correlation but that of a higher degree, therefore second degree, hyperbolic and exponential equations were fitted. The exponential equations gave the best fit, both with the observed values and the values obtained from empirical graphs. The empirical curves in fact turned out to be almost mathematical in their form and the differences in values obtained from the equations and the graphs were found to be insignificant. Differences between the values were generally in the second place of decimal (except for those whose averages were based on insufficient data) and the difference in the sum of squares of deviations was in the first decimal.

Bahraich data

Original data recorded as girths stump-height for corresponding girths breast-height. It was arranged in 3″ girth classes and the weighted averages were transformed to diameters. Average diameter stump-height was then plotted against average diameter breast-height and a smooth curve was drawn.

Equation of closest fit :

$$Y = 21 \cdot 97 \times (1 \cdot 0207)^{x}$$

where Y is girth stump-height and x is girth breast-height.

TABLE I

(Values read from empirical curve ; those in brackets are extrapolated).

Diameter S.H. inches	Diameter B.H. inches	Diameter B.H. inches	Diameter S.H. inches
12·0	(8·6)	8·0	(11·7)
13·0	(9·8)	9·0	(12·5)
14·0	(10·8)	10·0	(13·3)
15·0	(11·8)	11·0	(14·2)
16·0	12·8	12·0	15·1
17·0	13·9	13·0	16·1
18·0	14·8	14·0	17·2
19·0	15·6	15·0	18·3
20·0	16·4	16·0	19·5
21·0	17·2	17·0	20·8
22·0	17·8	18·0	22·3
23·0	18·5	19·0	23·8
24·0	19·1	20·0	25·4
25·0	19·7	21·0	(27·0)
26·0	20·4	22·0	(28·6)
27·0	(21·0)		
28·0	(21·6)		

Tarai & Bhabar data

Original data in diameters. It was classified in one inch diameter classes and weighted averages were plotted and a smooth curve was drawn.

Equation of closest fit :

$$Y = 6 \cdot 548 \times (1 \cdot 063)^{x}$$

where Y is diameter stump-height and x is diameter breast-height.

TABLE II

(Values read from empirical curve ; those in brackets are extrapolated).

Diameter S.H. inches	Diameter B.H. inches	Diameter B.H. inches	Diameter S.H. inches
16·0	14·6	13·0	(14·5)
17·0	15·6	14·0	15·4
18·0	16·6	15·0	16·4
19·0	17·7	16·0	17·4
20·0	18·4	17·0	18·5
21·0	19·1	18·0	19·6
22·0	19·9	19·0	20·9
23·0	20·7	20·0	(22·2)
24·0	(21·3)	21·0	(23·6)
25·0	(21·9)	22·0	(25·2)

SURFACE GEOLOGY, VEGETATION AND PLANT SUCCESSION

BY DR. G. S. PURI, M.SC., PH.D. (LUCK. & LOND.), F.L.S., F.G.S.*

(A paper read before the Botany Section of the Indian Science Congress in January 1949)

Introduction.—As a dominant wood forming tree in Britain *Fraxinus excelsior* either forms a pure ash community or enters into the woods of either species of *Quercus* forming an ash—oak community.

Pure ash woods are confined to limestone rocks and obviously their distribution is governed by the soil of calcareous nature.

The ash—oak community occurs both on calcareous as well as on non-calcareous soils. The distribution of ash in the ash—oak woods on non calcareous slaty rocks in the north of England has been found to be related to immature soils of high base status and high pH values (Puri, 1949 b, 1949 c).

In the South and Midlands of England the ash—oak community has been considered by Watt (1934) and Tansley (1939) to be a successional stage leading to the climax beech forests on the Chilterns and the South Downs.

It is, however, commonly believed that ash is confined in oakwoods to calcareous patches of soil and to damp places (cf. Tansley). In the oak-hornbeam woods of Hertfordshire, which according to Watt (*loc. cit.*) are "regarded as an oak-hornbeam associes with beechwood as the potential climax", Salisbury (1916–18) has similarly shown that ash occurs in wetter parts or in less acidic dry places, where Chalk is close to the surface.

Watt, on the other hand, believes that the poor development of ash associes on the Chilterns is due to a very continental climate and grazing. But a critical examination of Watt's data from the plateau woods seems to show that the absence of ash—oak and especially of ash stage from seres B and C is related to low pH value, low percentage of exchangeable calcium and low basicity of the soil.

In view of these considerations it seemed desirable to investigate the factors, especially in the soil, governing the distribution of ash as well as other tree species in some south of England woods. This has necessitated the study of plant succession in this area, and in the light of soil data an attempt has been made to discuss the relationship of beech to oak, ash and other common trees.

The following four examples were studied.—

(i) Whippendell woods, near Watford, Hertfordshire.

(ii) Beechwoods near Aldbury, Chiltern Hills.

(iii) Box Hill, North Downs, Surrey.

and (iv) Epping Forest.

(i) WHIPPENDELL WOODS

These woods presumably belong to the beech forests of the Chilterns area and floristically show a fairly close resemblance to Seres A_0 and A from the plateau woods of the Chiltern Hills. The successional stages leading to the beech forests in these two seres according to Watt are : "Grassland"→scrub→developing ash-oak woodland→oak wood→beech associes→beech-wood. Watt states that most of the oak woods in this region are planted, so it can only be assumed that they represent a successional stage. Beechwoods were also largely planted and ash associes is not well developed. On account of the soil deterioration brought about by *Fagus sylvatica* Watt further maintained that the beech community cannot be regarded as a climatic climax for indefinitely long periods and "the ultimate fate of the beechwoods would be retrogression to heath" (*loc. cit.*, p. 998).

In the Whippendell woods, however, no such extreme tendency was witnessed, and the deterioration of the soil (low pH, low base status, low nitrate, high organic matter, etc.) at some places runs parallel with whatever conditions are suitable for the regeneration of beech in these woods.

The major part of the vegetation was developed in a valley and on its surrounding ridges. The ridge adjoining the golf course is very steep. The valley in the centre is more or less level. The opposite ridge has a very gentle slope. At its top it imperceptibly merges into a more or less flat part of the woods, though there are local depressions and gullies.

* Contribution from Deptt. of Botany, University College, London.

The chief geological rock in this region is Chalk, which is covered over by clay-with-flints deposits. Along the lower level of the ridges and in the valley the Chalk is overlain by Glacial Gravel of the Pleistocene Age. This deposit is mainly sandy or loamy with stones of varying sizes. As a result of this superficial covering the outcrops of Chalk rarely appear on the surface.

A greater part of the vegetation in these woods has been subjected to severe human interference. Felling and replanting of beech, has been practised for a considerably long time and most of the mature trees of beech (200–250 years old) are understood to have been originally planted.

VEGETATION

(TABLES 1–3, FIGS. 1 & 1a)

(1) *First ridge.*—The major plant community on upper parts is beech—oak—hawthorn ; the beeches are mainly mature trees, accompanied by hornbeam, oak and birch. Standards and saplings of oak are fairly common though mature trees are more numerous.

By far the commonest tree seedlings are those of beech and hawthorn, however, seedlings of oak, birch, hornbeam and holly are also present. Beech and hawthorn are regenerating at some places, while at others seedlings of holly are the only ground flora species under mature beeches. Oak seems to regenerate successfully, though very slowly.

TABLE 1. A—Percentage distribution of trees around quadrats in each of the areas.

B—Percentage distribution in each area of quadrats in which tree seedlings of named species were found.

Total No. of quadrats	First Ridge 28		Valley 36		Second Ridge 24		Top part of ridge 25	
	A	B	A	B	A	B	A	B
Acer pseudoplatanus	24	11	58	..	59	21	95	36
Betula pubescens ..	48	14	40	..	54	4	70	4
Carpinus betulus ..	48	11	..	..	..	..	..	..
Cornus sanguinea ..	..	..	14	..	8	..	..	..
Corylus avellana ..	28	7	70	..	86	..	50	..
Cratægus mongyna ..	76	53	36	3	8	5	..	16
Fagus sylvatica ..	68	71	12	2	..	7	16	22
Fraxinus excelsior ..	40	45	90	58	59	42	25	26
Ilex aquifolium ..	..	11	..	..	..	..	..	4
Picea sp. ..	7	..	41	..	..	..	..	..
Prunus avium ..	10	..	22	..	..	..	..	..
Prunus padus ..	..	..	..	..	12	8	16	4
Quercus robur ..	48	14	70	4	58	3	80	4
Sambucus niger ..	32	..	70	..	58	..	48	..

TABLE 2. Percentage distribution in each area of quadrats containing given types of ground flora.

Total No. of quadrats	First Ridge 27	Valley 48	Second Ridge 28	Top flat part of the ridge 32
Bare areas ..	14·8	2·5	7	9·3
Scilla-Rubus ..	18·5	25·0	18·0	25·0
Scilla-Pteridium ..	–	12·5	14·2	12·5
Chamanerion ..	7·4	22·9	21·4	46·8
Brachypodium ..	25·9	4·1	–	–
Mercurialis ..	25·9	25·0	21·4	9·3
Mercurialis-Urtica ..	7·4	12·5	18·0	–
Urtica ..	–	4·1	3·5	6·2

The chief ground flora communities are *Scilla-Rubus* (18·5%) and bare areas (14·8%). In recently felled places a *Chamanerion* community is prominent (Fig. 1a).

Tree percentage of beech, hornbeam and also hawthorn decreases from top to bottom of this ridge (table 3). On lower levels, ash and hazel often accompanied by sycamore are present. At one or two places (cf. table 3, quadrats 44, 45) tree percentage of ash was high and along transect 4 saplings of ash ascend to the top of this ridge. Tree seedlings here are mainly those of ash, though a few sycamore and an isolated hazel or two were also found.

The chief ground flora communities along lower levels are *Mercurialis* and *Brachypodium*.

TABLE 3. Percentage distribution of trees around quadrats and soil conditions along each of the transects from the Golf course into the main body of the Whippendell woods.

Explanation of symbols used in this table (also Figs. 2–7) and all others in the text.

ca = calcareous soil.
o = Base saturated soil.
1–3 = Signify increasing base deficiency in the soil.
– = Trees felled from the area recently.

Note.—Base status of the soil was determined by shaking a little soil in alcoholic solution of Potassium thiocyanate and noting the intensity of the red coloration produced. 1–3 refer to increasing base deficiency in the soil and is judged from the increasing intensity of red coloration. Colourless solution signifies that soil was base saturated.

Calcareous soil was that which produced effervescence with dil Hcl.

	First ridge (Top to bottom)					Valley			Second ridge (Bottom to top)			Plain part of the woods			
TRANSECT No. 1															
Quadrat Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fagus sylvatica	40	60	59	–	41	4	–	–	–	–	–	–	–	–	–
Carpinus betulus ..	–	–	39	30	41	–	–	–	–	–	–	–	–	–	–
Quercus robur	–	–	1	–	–	4	4	–	10	–	3	5	–	4	2
Betula pubescens ..	–	–	1	–	–	16	8	5	10	–	–	–	5	–	4
Cratægus monogyna ..	60	40	–	25	17	40	–	–	–	–	–	–	–	–	–
Acer pseudoplatanus ..	..	..	..	10	..	8	64	..	5	22	15	45	76	64	94
Fraxinus excelsior ..	–	–	–	3	–	4	4	–	–	2	3	5	1	–	–
Corylus avellana ..	–	–	–	–	–	12	8	10	15	55	36	15	14	–	–
pH	3·87	3·99	5·45	7·82	5·64	4·80	5·78	6·56	5·39	5·23	..	4·89	4·56	5·18	4·22
Base status	3	2	1	ca	o	1	1	o	o	o	..	1	2	o	2

	First ridge (Top to bottom)						Valley				Second ridge (Bottom to top)					Plain part of the woods				
TRANSECT No. 2																				
Quadrat Nos.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Fagus sylvatica	33	8·3	–	–	–	3·3	–	–	–	–	–	–	–	–	–	–	–	–	2·2	–
Carpinus betulus ..	33	–	7·1	16·6	8·3	54·4	22·5	–	–	–	–	–	–	–	–	–	–	–	–	–
Quercus robur	33	–	21·4	16·6	8·3	–	–	5	2·5	–	–	9·1	6·6	2	1	8·5	2	–	4·4	–
Betula pubescens ..	–	–	–	–	12·5	33·3	–	7	–	–	33·3	12·5	5·0	–	1·5	3	–	–	4·4	–
Cratægus monogyna ..	–	83·3	7·4	66·6	68·2	6·6	2·5	4	2·5	3·5	–	–	–	–	–	–	–	–	–	–
Acer pseudoplatanus ..	–	–	–	–	–	–	–	3	–	–	18·3	3·0	5·0	3	2	57·1	90	100	88·8	–
Fraxinus excelsior ..	–	–	–	–	–	–	62·5	70	50	96·5	35·0	66·6	50	94·2	4·5	8·5	–	–	–	–
Corylus avellana ..	–	–	–	–	–	–	7·5	8	–	–	3·5	10·5	33·3	14·2	60	11·4	–	–	–	–
pH	4·00	4·51	4·84	4·9	5·38	5·10	5·55	4·21	4·68	4·62	5·99	5·12	4·64	5·32	..	5·11	4·88	4·62	5·12	–
Base status	2	3	2	1	1	o	1	o	1	1	o	1	1	o	..	o	1	1	1	..

	First ridge (Top to bottom)					Valley						
TRANSECT No. 3												
Quadrat Nos. ..	41	42	43	44	45	46	47	48	49	50	51	52
Faegus sylvatica ..	13·2	3	40	13	10	2	1·5	–	–	–	–	–
Carpinus betulus ..	5·5	6·6	–	–	–	–	–	–	–	–	–	–
Quercus robur	40·9	11·4	6·6	–	–	1·2	4·1	2·0	10	6	7	–
Betula pubescens ..	5	23	33·3	–	2	–	1·5	7·0	10	–	14·2	12
Cratægus monogyna ..	40·9	40	9	6	6	22	4·1	7·0	5	–	–	–
Acer pseudoplatanus ..	–	–	–	2	2	–	–	13·2	25	4	5	6
Fraxinus excelsior ..	–	11·4	–	68	80	72	75	70	25	80	64	45
Corylus avellana ..	–	–	–	10	–	2	–	–	5	2	7	33
pH	4·32	4·80	4·63	6·58	7·90	6·23	5·12	4·82	4·26	5·23	5·19	5·29
Base status	3	1	2	ca	ca	o	1	1	2	o	o	o

	First ridge (Top to bottom)									
TRANSECT No. 4										
Quadrat Nos.	**69*a***	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**
Fagus sylvatica	**6·2**	**–**	**5**	**3**	**10**	**–**	**–**	**3·1**	**–**	**–**
Carpinus betulus	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Quercus robur	**12·5**	**–**	**5**	**3**	**–**	**12**	**–**	**–**	**2·6**	**20**
Betula pubescens	**30**	**24**	**35**	**–**	**–**	**–**	**–**	**3·1**	**4**	**–**
Cratægus monogyna ..	**50**	**64**	**20**	**–**	**–**	**30**	**20**	**–**	**1**	**–**
Acer pseudoplatanus ..	**–**	**–**	**–**	**–**	**–**	**–**	**15**	**3·1**	**2·6**	**2**
Fraxinus excelsior	**–**	**4**	**7·5**	**78**	**70**	**48**	**50**	**83·3**	**80**	**55**
Corylus avellana	**–**	**–**	**10**	**12**	**20**	**18**	**–**	**–**	**2·6**	**2**
pH	**4·09**	**4·94**	**4·84**	**8·26**	**7·99**	**7·61**	**8·21**	**5·74**	**4·14**	**4·73**
Base status	**2**	**1**	**1**	**ca**	**ca**	**ca**	**ca**	**o**	**1**	**1**

Second Ridge (Bottom to top)								Plain part of the woods							
53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
–	–	–	–	–	–	–	–	25	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4	–	10	4	–	15	9	8	20	10	11	16	15	3·5	–	10
14	12	–	8	50	30	12	28	15	50	20	28	–	13	16·3	45
5	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–
25	38	30	24	24	50	90	50	30	70	63·7	36	40	72	63·6	30
35	27	60	20	–	–	–	–	–	–	–	–	–	–	–	–
4	9	6	6	–	–	–	–	–	–	–	–	–	–	–	–
5·21	5·11	5·42	5·25	4·66	4·08	4·7	–	4·19	4·60	4·19	4·86	–	4·87	4·84	4·54
1	1	o	o	2	2	1	–	2	2	2	1	–	1	1	2

Valley				Second Ridge (Bottom to top)						Plain part of the woods				
79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3	–	–	2	–	4·4	–	8	9	6	8	3	8	12	–
–	1·5	–	–	–	–	–	–	34	12	20	3	–	6	28
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5·5	1·5	–	16	22	40	55	80	60	66	24	86	64	75	64
85	81·5	23	36	22·2	11	22	–	–	12	–	15	12	6	8
4·0	10·9	3	6	6	8	–	–	–	6	12	3	3	6	–
4·71	4·86	5·36	4·81	4·97	4·17	4·75	4·00	4·68	5·00	4·22	5·14	4·58	4·42	4·64
1	1	o	1	1	2	1	2	1	1	1	1	1	2	1

(2) *Valley*.—The major part of the valley is occupied by an ash—oak community. Trees and saplings of ash are generally more numerous than those of oak, but at some places oak, accompanied by elm greatly outnumbers ash, standards of oak are rather rare. Hazel and sycamore, mainly saplings, and birch (mainly in felled areas) are present.

Tree seedlings are chiefly those of ash but are not numerous. Some seedlings of oak and beech are present in the area dominated by oak trees. Under mature trees of ash and oak there is very little regeneration of ash.

The chief ground flora types in the valley are *Scilla-Rubus* and *Scilla-Pteridium* though under saplings of ash and in local depressions *Mercurialis* community is prominent. *Chamanerion* community occurs at felled places and on top of depressions.

(3) *Second ridge*.—The main tree community here is ash—oak—hazel which along upper parts gets replaced by oak—sycamore—birch. Saplings and standards of ash are more numerous than mature trees. Hazel is coppiced in this part. Of sycamore mature trees are more numerous though saplings and standards are quite common. Oak and birch are mature trees and are felled from many places.

Tree seedlings along lower slopes are mainly ash, along upper levels sycamore are numerous. Under mature trees of sycamore seedlings of beech, hawthorn and oak are present. Seedlings of birch were seen in recently felled areas.

The chief ground flora types along lower levels are *Mercurialis* and *Mercurialis-Urtica* ; along upper levels, however, *Scilla-Rubus* and *Scilla-Pteridium* were common.

(4) *Top level part of the wood*.—This part bears oak—birch or oak—birch—sycamore community. Sycamore is present as a shrub and seems to be coppiced. A few mature trees of beech are present. Oak trees belong to all age classes.

Tree seedlings are those of sycamore, however, under beeches seedlings of *Fagus* and hawthorn, which do not seem to mature, are present. Under mature beech seedlings of holly were seen, though there were no holly shrubs in this area. Ash seedlings were found in local depressions.

The chief ground flora types are *Scilla-Rubus*, and *Scilla-Pteridium*. *Mercurialis* community was found in local depressions and under saplings of sycamore. On felled areas and top rims of depressions *Chamaenerion* community was prominent.

It would thus seem that beech, hawthorn, hornbeam in these woods occur mainly on the upper parts of the valley sides. At some places they seem to regenerate, but at others beechwood apparently may pass into a holly type of vegetation. Here oak is fairly common and at places forms an oak—hornbeam community.

Ash and hazel occur mainly along lower levels where Chalk is close to the surface. The ash—oak community in the valley is on Glacial Gravel and at some places this seems to pass into a pure oak community.

In the remaining part of the wood on clay-with-flints oak is the single dominant plant, accompanied by birch and sycamore. From the abundance of oak in all parts of the woods it appears that oak community is probably the climax type.

In considering the distribution of various tree species in relation to soil conditions reference may again be made to table 3. It will be seen that there is no correlation between percentage frequency of trees of one species and pH value of the soil. There is, however, a close correlation of percentage frequency of trees of different species with base status of the soil, as is shown by Figs. 2–6.

The percentage frequency of beech (Fig. 2) and hawthorn (Fig. 3) shows a definite increase with a decrease in base status of the soil. Calcareous soils seem to be too rich for these species and their best development is seen in base deficient soils. This is in agreement with observations of Tansley (*loc. cit.*) who states that best development of beech is seen on acid loams overlying Chalk, which for the most part are deficient of calcium carbonate. It is also a dominant tree on sandy soils and on Pebble Gravel.

A similar relation between the tree percentage and base status of the soil is seen for oak (Fig. 4) and birch (Fig. 5). The frequency of both species shows a gradual decrease with an increase in base status of the soil. Like beech, lime rich soils do not seem to be very suitable for these species as well. Tansley's observations that both oak and birch are rare

on Chalk and that they occur on loamy, sandy or on siliceous soils are thus in agreement with the facts given above.

As shown in Fig. 6 the tree percentage of ash increases with an increase in base saturation of the soil and it shows its best development in base rich and calcareous soils. A similar relation is suggested for hazel. Tansley's observations that the best development of ash is seen in calcareous soils or in depressions and along streams where the soil is usually of a high base status, provide support for our conclusions. Hazel, according to him, is a dominant shrub on limestone and calcareous soils, and is commonly associated with ash in such associations. It will be noted that on sandy and base deficient soils, where oak, birch and beech predominate these species are significantly absent.

The relation between the base status of the soil and the percentage frequency of sycamore is shown in Fig. 7. Highest percentage of this species seems to occur in slightly base deficient soils ; and calcareous soils do not seem to be very favourable for it, though it does better than oak and birch on such soils.

With a view to test the general validity of the conclusions drawn above calcium content in the foliage of the different species was determined. The results are given in the following table.—

Species	*Bases as CaO on % dry weight*
Fraxinus excelsior	3·383
Corylus avellana	3·163
Cratægus monogyna	3·015
Acer pseudoplatanus	2·562
Fagus sylvatica	1·910
Quercus robur	1·873
Carpinus betulus	1·551
Betula pubescens	1·188
Castanea sativa	1·134

It will be seen that species occurring on calcareous or base rich soils have higher percentage of CaO in their leaf-litter and those occurring on poor, base deficient soils have low calcium content. The former group of species have exacting requirements and cannot maintain themselves for a long time on poorer sites.

(ii) BEECHWOODS, NEAR TRING

Introduction.—The distribution of the main tree communities in the Whippendell Woods was found to be related to the edaphic factor. With a view to seeing if the same factor governs their distribution in other areas as well, beechwoods near Tring in Hertfordshire were examined. These woods are north-east extension of the Chiltern beech forests and are developed on a steep hill-side, running north to south, and overlooking the village of Aldbury (Fig. 8).

This hill is formed of Chalk, the strata of which dip towards south-east forming a steep escarpment facing north-west and a dip slope towards south-east. Chalk outcrops appear at the surface along the escarpment, especially at the lower levels. On the dip slope Chalk is overlain by thick deposits of clay-with-flints, mixed here and there with Pebbly Gravels and Sands.

The interesting feature of the vegetation of this region is that while the scarp slope bears a mixed woodland (of beech, ash, hawthorn), scrub or Chalk grassland (only in cleared and grazed parts), tree communities on the dip slope are mainly Birch-oak and Birch-oak-beech. In the cleared parts on the dip slope vegetation presents a heathy appearance with birch, gorse, *Deschampsia flexuosa* and an abundance of bracken.

The vegetation on the scarp slope at Tring resembles floristically the hawthorn sere of Watt from the Chiltern escarpment, and with escarpment woods on the South Downs. The plant succession in these areas found by Watt is ; Chalk grassland→hawthorn scrub→poorly developed ash wood→beechwood (mercury).

The plant communities on the dip slope show a remote resemblance with some oak and beechwoods included by Watt in Seres B and C, from the plateau woods of the Chilterns and with the vegetation of area 4 in the Whippendell woods.

VEGETATION

(Tables 4–6, Figs. 9 and 9a)-

(i) *Scarp slope.*—The main tree community on upper levels is beech, the lower levels being usually occupied by ash or ash—hazel—

TABLE 4

Tree Vegetation on the escarpment

Percentage distribution of trees around quadrats along each transect and soil features from upper to lower levels on western slope

	TRANSECT No. 2									TRANSECT No. 3								TRANSECT No. 4				
Quadrat Nos.	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Acer pseudoplatanus ..	–	–	–	–	–	–	–	–	9	–	–	–	–	–	–	–	–	–	–	–	–	12
Corylus avellana ..	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	24	..	..
Cratægus monogyna ..	–	–	–	–	20	–	–	–	17	23	–	–	7	37	–	6	–	–	–	8	–	30
Fagus sylvatica ..	100	100	30	19	40	87	91	75	38	30	93	55	53	12	33	33	28	60	42	16	50	15
Fraxinus excelsior ..	–	–	20	25	13	–	–	–	–	–	–	–	15	6	–	–	–	20	–	–	–	–
Ilex aquifolium ..	–	–	10	25	26	–	–	19	12	15	7	45	–	–	66	61	72	–	7	16	30	–
Larix sp. ..	–	–	–	–	–	13	9	6	3	–	–	–	–	–	–	–	–	–	14	12	20	12
Prunus padus ..	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	24
Quercus robur ..	–	–	15	–	–	–	–	–	–	7	–	–	7	12	–	–	–	–	–	–	–	–
Taxus baccata ..	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	8
Viburnum opulus ..	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–	–	–	–	–
pH ..	5·55	5·06	5·34	3·24	7·54	7·56	8·24	7·08	7·26	5·24	4·80	4·76	6·24	6·22	6·54	7·38	7·68	7·66	7·98	7·22	5·56	7·87
Base status ..	1	1	1	1	ca	ca	ca	o	ca	1	2	1	1	o	o	o	ca	ca	ca	ca	1	ca

	TRANSECT No. 6							TRANSECT No. 7						TRANSECT No. 8				TRANSECT No. 9			TRANSECT No. 10				
	50	51	52	53	54	55	56	57	58	59	60	61	62	87	88	89	90	91	92	93	94	95	96	97	98
Acer pseudoplatanus	–	–	–	–	–	–	–	–	16	–	7	15	–	4	–	13	15	62	52	69	–	–	–	3	12
Corylus avellana ..	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	2	–	–	–	–	6	8
Cratægus monogyna ..	62	55	40	–	30	–	–	52	28	40	66	–	–	12	16	13	10	20	–	–	–	50	49	13	4
Fagus sylvatica ..	–	–	30	20	–	–	–	20	16	13	–	–	–	12	4	18	5	3	5	–	–	100	6	10	8
Fraxinus excelsior ..	25	11	20	30	52	80	100	13	8	13	20	85	100	72	60	33	70	7	40	31	–	12	28	20	68
Ilex aquifolium ..	–	11	–	20	–	20	–	7	12	13	–	–	–	–	20	13	–	–	–	–	–	–	–	3	–
Quercus robur ..	12	–	10	20	–	–	–	7	12	13	–	–	–	–	–	–	–	–	–	–	–	12	4	–	–
pH	5·55	5·82	5·67	6·24	6·68	7·50	7·55	–	–	–	–	7·81	7·80	7·32	7·63	7·89	8·21	8·22	6·63	7·38	5·47	5·99	5·78	6·85	7·52
Base status ..	1	1	1	o	o	ca	ca	–	–	–	–	ca	ca	ca	ca	ca	ca	ca	o	ca	1	Tr	1	o	ca

TABLE 5

Tree vegetation on the dip slope

Percentage distribution of trees around quadrats along each transect and soil features
From the top of scarp slope towards heath

TRANSECT No. 1															
Quadrat Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Acer pseudoplatanus	–	–	8	–	–	–	–	–	–	–	–	–	–	–	–
Betula pubescens	–	–	–	–	–	–	–	–	40	26	15	88	100	100	80
Corylus avellana	–	25	–	8	6	20	–	13	–	–	–	–	–	–	–
Cratœgus monogyna	33	–	–	–	–	12	26	20	–	–	–	–	–	–	6
Fagus sylvatica	66	58	8	–	13	–	6	13	–	–	–	–	–	–	–
Fraxinus excelsior	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ilex aquifolium	–	8	–	–	–	6	–	–	–	–	–	–	–	–	–
Quercus robur	–	8	33	66	53	33	53	20	53	60	76	11	–	–	18
pH	6·15	5·19	4·80	4·56	4·39	4·26	4·12	4·00	3·75	3·79	3·88	3·85	4·08	4·00	3·99
Base status	o	Tr	1	1	2	2	2	2	3	3	3	3	2	3	3

From Heath towards the scarp slope

TRANSECT No. 5																				
Quadrat Nos.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Acer pseudoplatanus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Betula pubescens	50	54	95	85	25	10	11	7	–	75	–	75	10	53	50	–	10	–	–	–
Corylus avellana	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	30	40	10	–	–
Cratœgus monogyna	–	–	–	–	–	10	–	40	–	–	–	–	–	–	–	–	–	10	23	25
Fagus sylvatica	–	–	–	–	–	30	33	7	–	–	25	–	–	–	–	10	20	20	23	25
Fraxinus excelsior	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ilex aquifolium	–	–	–	–	–	–	–	–	–	–	16	–	–	6	–	–	–	–	7	6
Quercus robur	40	45	5	15	75	50	55	46	83	25	62	25	80	13	50	60	30	60	30	31
pH	4·77	3·82	3·62	3·53	4·21	4·69	4·79	4·37	4·62	4·01	4·42	4·22	4·05	4·32	4·08	4·92	5·10	5·24	4·89	5·68
Base status	2	3	3	3	2	2	2	2	2	3	2	2	2	2	2	1	1	1	1	1

No. of quadrats examined	Scarp slope 47	Dip slope 35
Betula pubescens seedlings ..	–	10
Cratægus monogyna seedlings ..	19	5
Fagus sylvatica " ..	27	–
Fraxinus excelsior " ..	76	–
Ilex aquifolium " ..	8	8
Quercus robur " ..	6	15
Taxus baccata " ..	3	–
Bare areas	18	–
Brachypodium sylvaticum ..	3	–
Chamænerion angustifolium ..	3	3
Mercurialis perennis ..	21	–
Mercurialis-Urtica dioca ..	12	–
Pteridium aquilinum ..	6	54
Deschampsia flexuosa ..	–	10
Rubus fruticosus agg. ..	34	34

sycamore. At some places beech may descend right to the bottom of the slope, but in such situations there is little regeneration and the wood comprised even-aged trees. On higher slopes beechwood contained trees of all ages, from mature to saplings, and regeneration was successful. The frequency of beech showed a decrease from the upper to the lower levels in all cases. On the other hand, tree frequency of ash was usually highest at the lower levels, decreasing towards the upper parts.

Tree seedlings at upper levels were those of beech and hawthorn. On lower levels seedlings of ash (and also sycamore) were more numerous even under beech.

The ground flora communities at upper levels were *Rubus fruticosus*, or bare areas ; at lower levels, however, *Mercurialis*, *Urtica-Mercurialis* and *Brachypodium* communities were present in most cases.

In enclosed parts of the Chalk grassland from which sheep were excluded the developing woodland had seedlings and saplings of ash, beech, hawthorn and sycamore. In the grazed part, however, hawthorn scrub was the main community. This seems to show that the grassland and scrub are purely artificial communities, controlled by biotic agencies.

(ii) *Dip slope.*—The main tree communities here are beech—oak—birch and oak. Beech is much less common and occurs mainly towards the scarp slope from where it seems to have migrated on to the dip slope. Oak is present throughout the woods on this slope and usually has a high frequency. Towards farther end of the dip slope oak is accompanied by birch, which outnumbers oak and the oak—birch community then passes into a heath. This heath seems to owe its origin to clear felling from this area, which was subsequently burnt, thus destroying soil organic matter. The presence of seedlings and saplings of birch and oak in the heath seems to show that heath and the birch community would pass into an oak wood, or oak—beechwood. The heath and the oak—birch community may thus be regarded as created by the biotic factor and a successional stage.

In the beech—oak—birch community birches are mainly mature trees. Both mature trees and standards were those of oak and beech. The ground flora community here was mainly *Rubus fruticosus* agg. Tree seedlings were mainly those of oak, holly and hawthorn. This community, thus seems to develop into a beech—oak or oak community.

Thus, it may follow that the climax community on the dip slope is oak or oak—beech. Heath and the oak—birch community, which were created and controlled by biotic agencies, are successional stages leading to the climax.

On the scarp slope beech and ash communities seem to be seral stages. The Chalk grassland and the scrub are biotic controlled successional stages.

It will be noted (tables 4–6) that in their distribution on the two slopes different tree species are related, as in the Whippendell woods, to base status of the soil. On the slope of the Chalk escarpment, especially at lower levels, Chalk outcrops appear on the surface. The soil here, therefore, remains lime rich. The flushing effect from above further helps to maintain this richness in bases and keeps it suitable for the ash community.

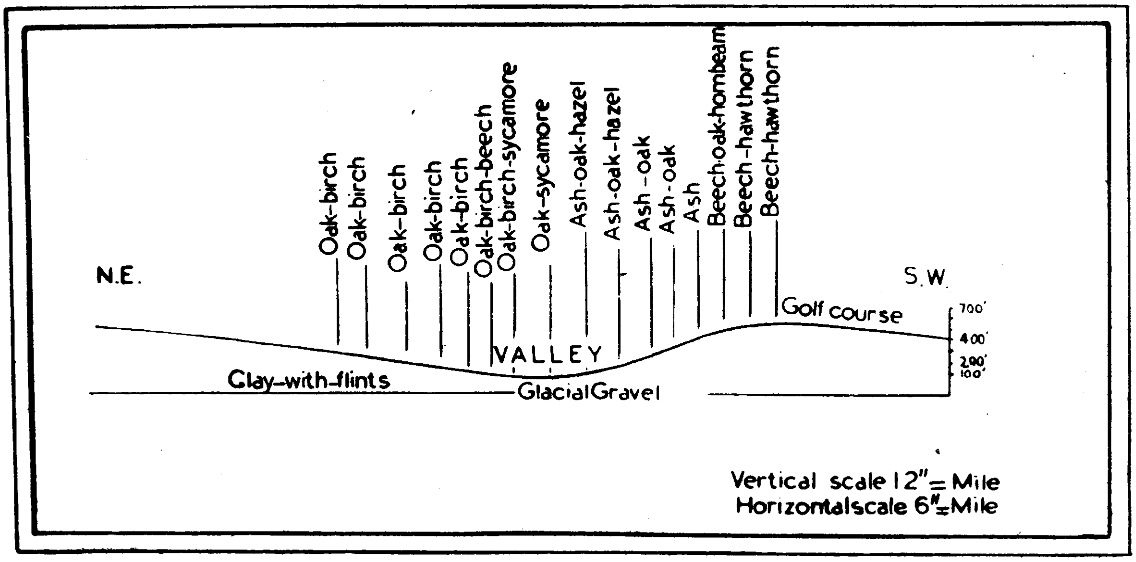


FIG. 1.—Relation of tree communities with surface geology in the Whippendell Woods.

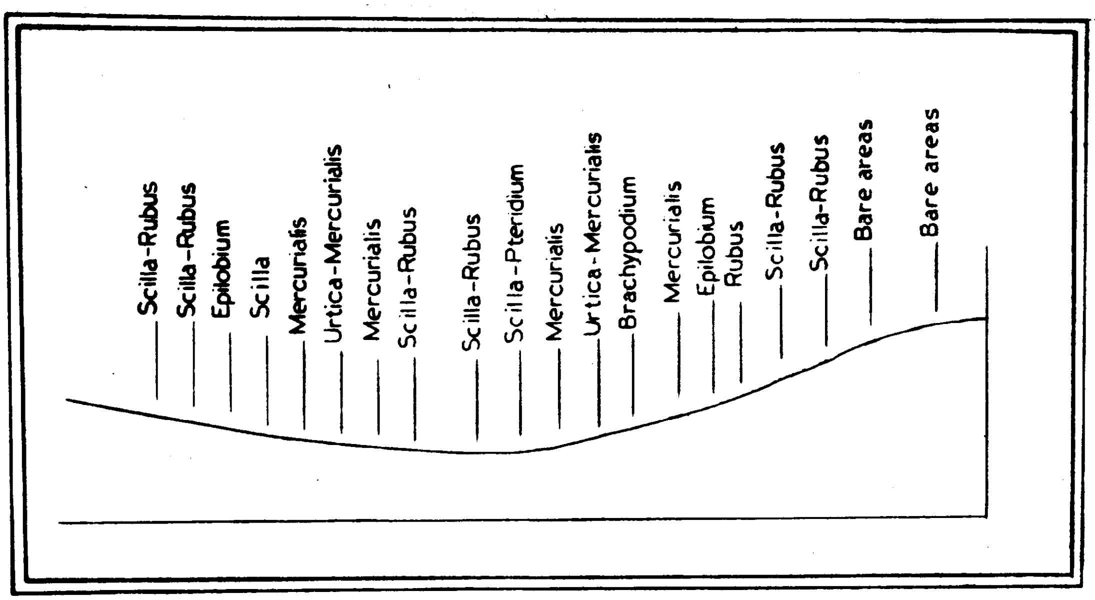


FIG. 1a.—Relation of ground flora communities with topography in the Whippendell Woods.

FIG. 2.

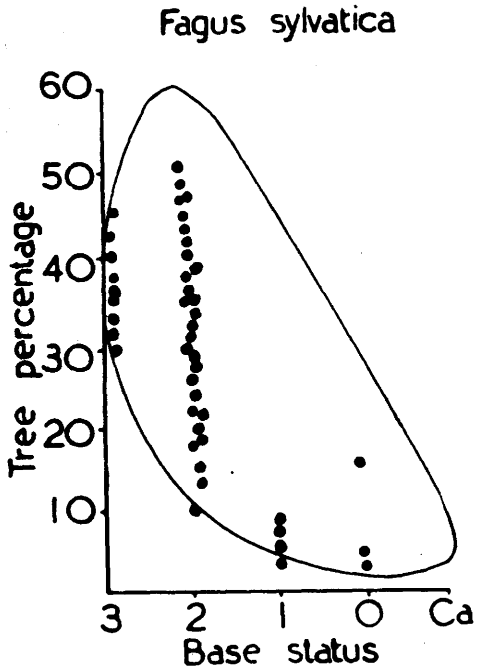
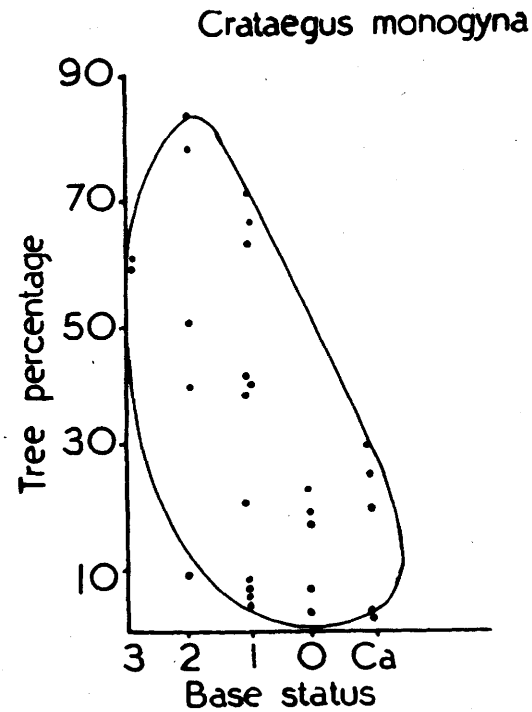


FIG. 3.



FIGS. 2, 3.—Relation between tree percentage and base status of the soil.

FIG. 4.

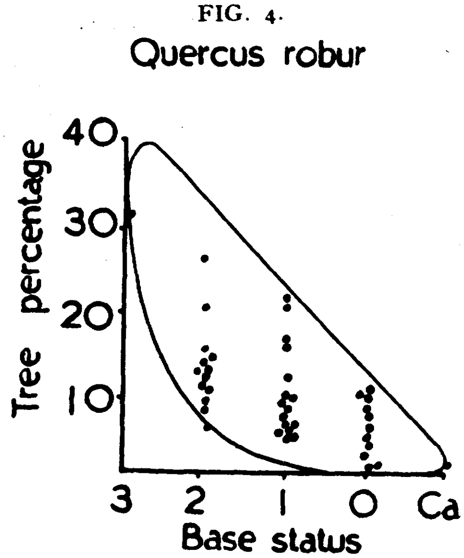
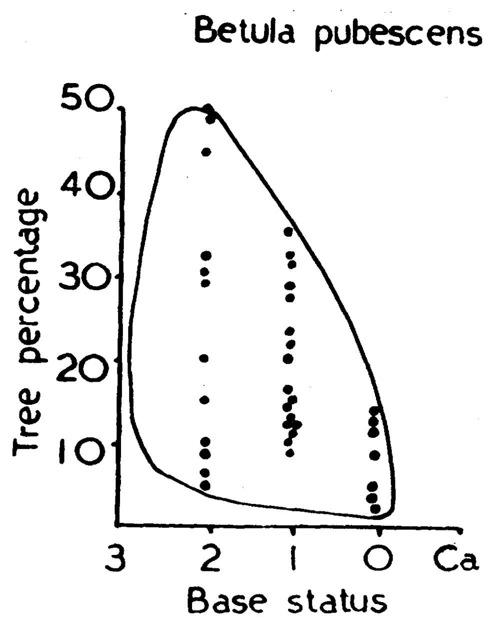


FIG. 5.



FIGS. 4, 5.—Relation between tree percentage and base status of the soil.

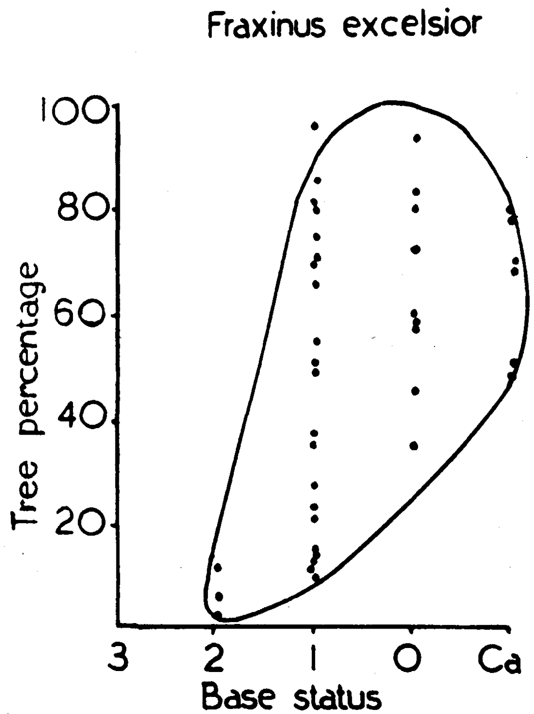


FIG. 6.—Relation between tree percentage and base status of the soil.

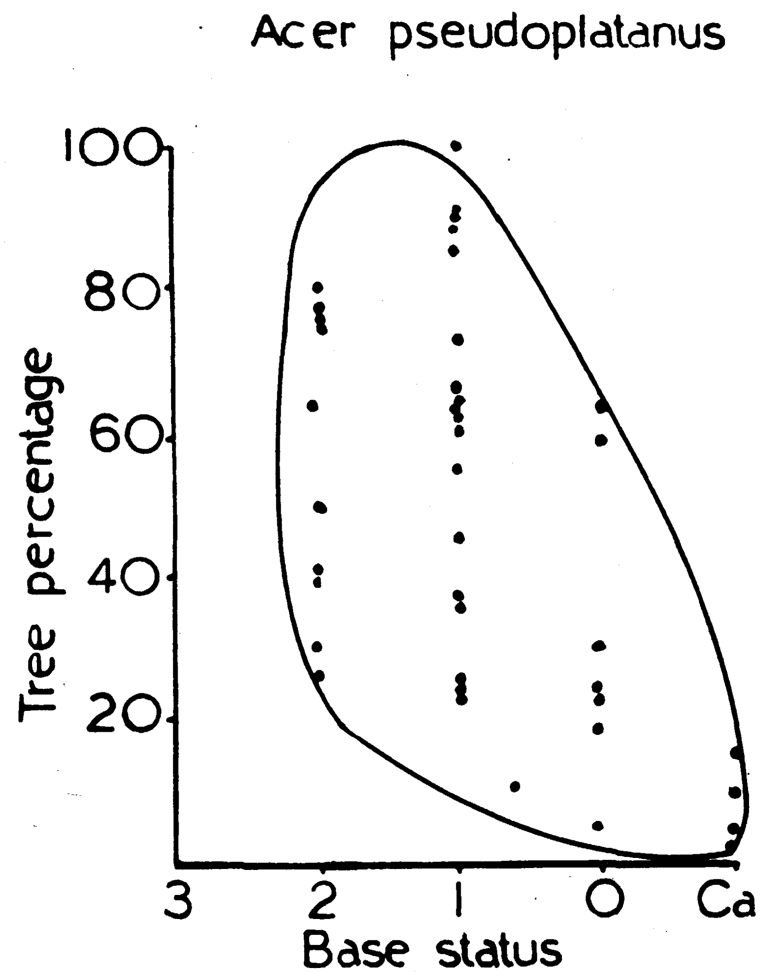


FIG. 7.—Relation between tree percentage and base status of the soil.

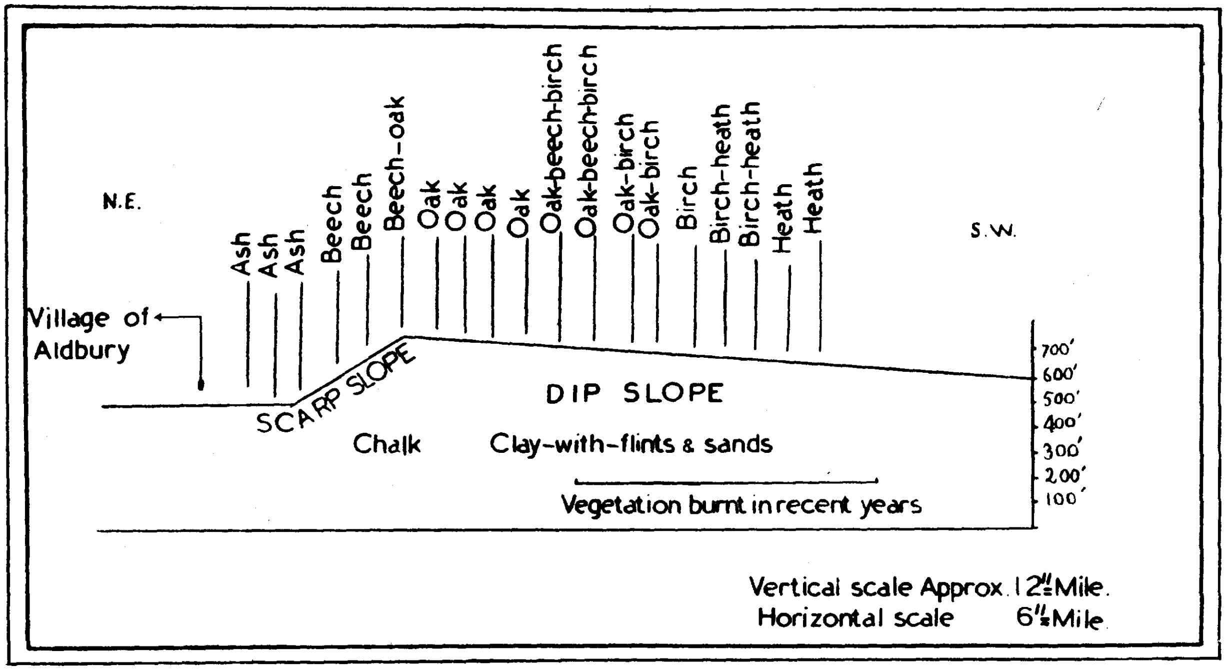


FIG. 9.—Distribution of tree communities on the two slopes of the Chalk at Aldbury, near Tring.

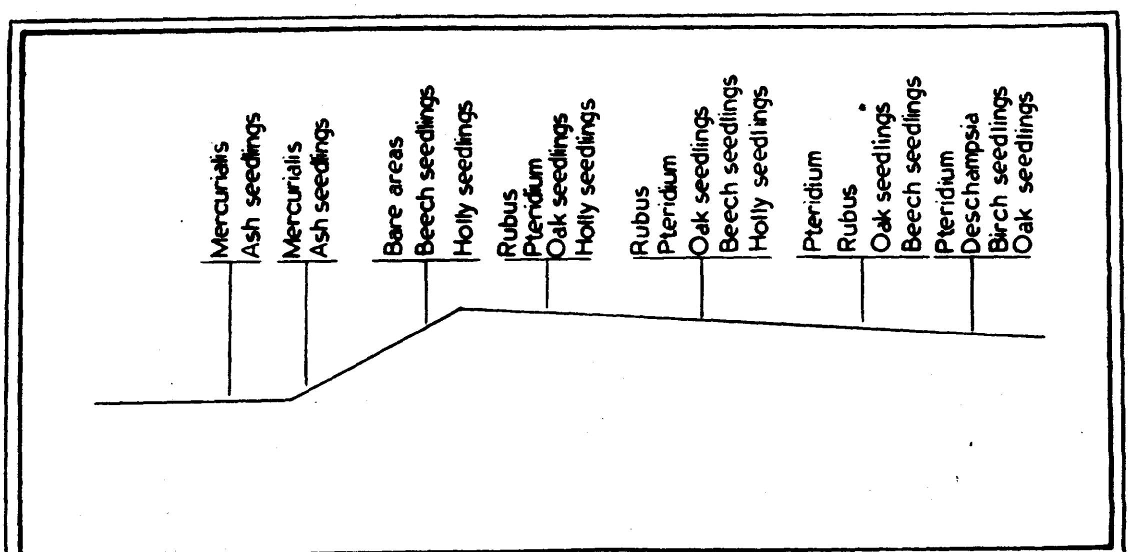


FIG. 9a.—The distribution of given types of ground flora and named species of tree seedlings at Aldbury (Tring).

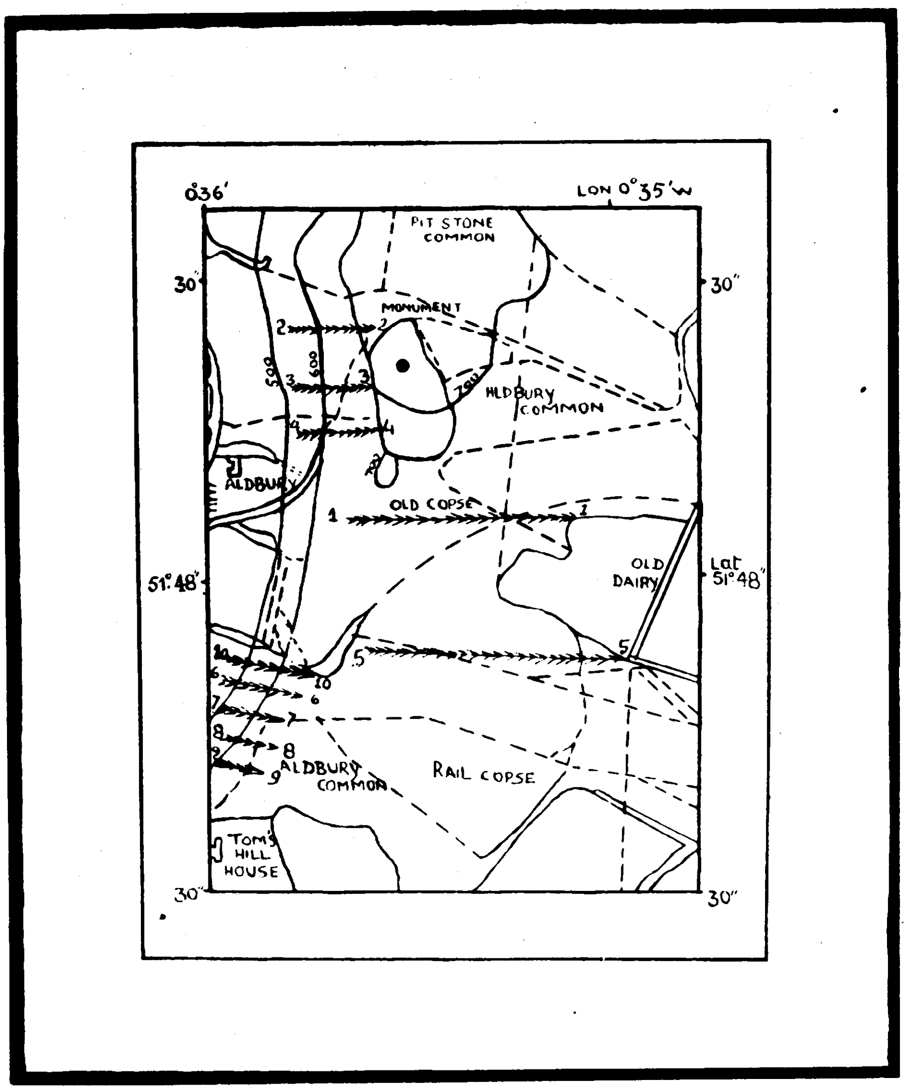


FIG. 8.—A marking position of transects studied at Aldbury (Tring).

Scale 6″ = 1 mile.

Along upper levels, on account of the greater intensity of leaching, the surface soil develops deficiency in bases, on which occurs the beech community. Thus, it seems that on the scarp slope soil conditions and vegetation types tend to follow topography.

On the dip slope the Chalk is much below the surface and on account of the absence or small amount of lime in the overlying deposits of Clay-with-flints and Gravels, the surface soil tends to become much more base deficient than on the scarp slope. In such soils oak and oak—beech communities find their best development.

Thus, it may follow that in this region the differences in the nature of soil and vegetation are brought about by the dip of the strata of the Chalk. Human agency has disturbed the climax vegetation, and created some artificial successional communities.

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A NOTE ON THE PRACTICAL APPLICATION OF THE RECOMMENDATIONS MADE IN THE INDIAN FOREST BULLETIN No. 141*, REGARDING THE FORECASTING OF THE QUALITY OF TEAK FROM THE SOIL AND SITE CHARACTERISTICS

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The four factors utilized for forecasting the quality of teak that is likely to be obtained on a particular site, when the natural forest is clearfelled and planted with teak, as given in I.F. Bull. No. 141*, are as follows :—

(1) Ratio of Silica to Sesquioxides (SiO_2/R_2O_3 ratio).

(2) Dispersion Cœfficient.

(3) Depth of permanent moisture availability and

(4) Aspect.

In the Bulletin above mentioned, curves have been given at the end and all that a Forest officer needs is to determine these four factors and read the corresponding AIQ for teak that would be expected on the site according to each individual factor. These curves are reproduced at the end of this note for ready reference. Next comes the question of combining all these factors and thus obtaining the resultant forecast for the All-India Quality of teak that would be expected on a particular site on the basis of the soil and site factors. In order to make the process of calculation clear and practicable, an example is given below :—

In the locality of pit 4B of Kanhirakadavu, in Conversion Working Circle, Nilambur Dn., South India, the following forecasts were read off on the basis of the four individual soil and site factors, taking the bottom depth of soil (48″–72″) into consideration for the former.

(1) Basis of SiO_2/R_2O_3 ratio, AIQ read off from curve = 0·3III.

(2) Basis of Disp. Cœff., AIQ read off from curve = 0·3II.

(3) Basis of Perm. Moisture Av., AIQ read off from curve = 1·8II.

(4) Basis of Aspect, AIQ read off from curve = III (taken as 1·0III).

Now in order to obtain a combined AIQ forecast we have to combine the four individual factor-forecasts namely 0·3III, 0·3II, 1·8II, and 1·0III, considering all of them having equal influence values. This is obtained as follows :—

Combined AIQ

$$= \frac{0\cdot3\,(\text{III})+0\cdot3\,(\text{II})+1\cdot8\,(\text{II})+1\cdot0\,(\text{III})}{4}$$

$$= \tfrac{1}{4}\,[0\cdot3\,(\text{III})+0\cdot3\,(\text{II})+1\cdot8\,(\text{II})+1\cdot0\,(\text{III})]$$

$$= \tfrac{1}{4}\{0\cdot3\,(\text{III})+(0\cdot3+2\cdot0)\,(\text{III})+(1\cdot8+2\cdot0)\,(\text{III})+1\cdot0\,(\text{III})\}$$

$$= \tfrac{1}{4}\,(0\cdot3+0\cdot3+2\cdot0+1\cdot8+2\cdot0+1\cdot0)\ \text{III}$$

$$= \frac{7\cdot4}{4}\,\text{III} = 1\cdot85\ \text{III or } 1\cdot9\ \text{III}$$

Thus the forecast for the quality of teak to be obtained in the area was AIQ 1·9 III†. In the above calculations, all the forecasts are resolved into a single quality (in this case AIQ III) and then combined for calculating the average, e.g.

$$0\cdot3\ \text{II} = (0\cdot3+2\cdot0)\ \text{III}$$
and $$1\cdot8\ \text{II} = (1\cdot8+2\cdot0)\ \text{III, etc., etc.}$$

Of the four factors, the last two namely, the "Depth of Permanent Moisture Availability" and "Aspect", are site factors and can be noted in the field. The first two namely, the "ratio of silica to sesquioxides" and "dispersion cœfficient" have to be determined on analysis of the soil in the laboratory. These however, could be determined in a field

* Griffith, A. L. and Gupta, R. S. (1947–48). "Soils in relation to teak with special reference to laterization" (Ind. For. Bull. 141).

† Readers will be interested to learn that the AIQ actually assessed in this locality in a 5-year old plantation in Sq. 8·8 planting rows were as follows :—

On the basis of the tallest tree	1·0 II
On the basis of an avarage of 5 tallest trees	0·5 II
On the basis of a average of 10 tallest trees	1.5 III

Thus the forecast was correct within half a decimal quality. It is expected that as the plantation advances in age the forecast will tally better with the actual AIQ in the field.

laboratory by an intelligent forester, after a little training and by modifying the textbook methods here and there. In the present paper an attempt is made to specify these methods of determinations which could be done in a field laboratory. The methods are all textbook methods and no originality is claimed by the author, but as he has actually worked them up in a field laboratory which was set up by him at the Government Fruit Research Station at Chaubattia (U.P.), he is confident that the method is practical and recommends them to the Silviculturists, particularly in the areas where teak is intended to be grown. The field laboratory methods of determination for the four factors are given below.

1. *Ratio of silica to sesquioxides.*—For purposes of the investigation this ratio is defined as the ratio of gm. mols. of total SiO_2 to R_2O_3 (i.e., sum of $Fe_2O_3+Al_2O_3$) in 100 gms. of the soil. For this determination the soil sample is finely ground for analysis (*n.b.* for the collection of soil samples. See Bull. No. 135)*. The sample is first passed through 2 mm. sieve after grinding with a wooden mallet, and then this 2 mm. sieved sample is ground in a porclain mortar and pestle so fine as to enable the whole of it to pass through a 50 mesh sieve. The fine soil powder so obtained is dried in an air-oven at 105°C, then kept dry in a dessicator and utilized for analysis.

2 gm. of the fine soil powder is weighed and transferred into a 400 c.c. beaker. 50 c.c. of tri-acid mixture† is poured on the soil, the beaker covered with a watch glass and heated on a sand-bath placed on a small stove in a fume cup-board. When the brown nitrous fumes have ceased to evolve, the watch glass is withdrawn partially to a side to allow the fumes to come out freely. The heating is continued for one more hour till white fumes of sulphur-dioxide are freely given off and the mixture assumes a pasty consistency. The beaker is now allowed to cool. 100 c.c. of distilled water are added carefully. The beaker is gently heated again until all the salts are dissolved and the solution is reduced to 50–60 c.c. The mixture is filtered, the residue thoroughly washed with distilled water and the filtrate collected in a 400 c.c. beaker. The filtrate is again evaporated on a sand-bath until white fumes of sulphur-di-oxide are evolved, and then cooled. 100 c.c. of distilled water is then added and the solution boiled again to reduce the volume to about 50 or 60 c.c. The solution is then filtered in the original filter paper, the precipitate then washed with hot distilled water and the filtrate collected in a 100 c.c. graduated flask. The filtrate is made up to 100 c.c. when cool. The silica on the filter paper is dried in an air-oven, transferred to a weighing dish and weighed after adding the filter ash (which is deducted from total weight) and the percentage of total silica calculated.

The filtrate is utilized for the estimation of sesquioxides (oxides of iron and aluminium). 25 c.c. of the filtrate is then taken in a 250 c.c. beaker and 10 c.c. of 10% ammonium chloride solution is added followed by slight excess of ammonia (25% solution) till a precipitate of R_2O_3 (sesquioxides or the oxides of iron and aluminium) is obtained. The beaker is heated and the contents are boiled for a few minutes, after covering the beaker with a watch glass, till it scarcely smells of ammonia. Before the contents settle down, they are filtered in a filter paper (with a known weight of ash) and washed with distilled water thoroughly to free it from sulphate. For testing the filtrate, it is taken in a test tube, acidified with nitric acid (a few drops) and two drops of barium chloride solution (10%) are added. The sulphate will give a white precipitate. When the precipitate of R_2O_3 is free from sulphate, it is dried in an air-oven, transferred to a weighed crucible, the filter paper ashed and added to the precipitate, ignited on spirit burners and cooled in a dessicator and weighed. The percentage of R_2O_3 is calculated.

Iron oxide (R_2O_3) is determined separately. For this, 25 c.c. of the filtrate is taken in a 300 c.c. conical flask. 25 c.c. distilled water and 5 c.c. concentrated sulphuric acid are added. The iron sulphate is reduced by putting into the solution some small pieces of pure grannulated zinc, which when acted upon by the acid evolves hydrogen which reduces the iron sulphate. Completing of the reduction is tested by adding a drop of the solution to a drop of 1% ammonium thiocyanate on a white porclain piece (say a porclain dish) till it gives no red coloration. The solution is then

* Griffith, A. L. and Gupta, R. S. (1947). The Recording of soil and site characteristics in the field. (I.F. Bull. No. 135).
† *Tri-acid mixture:* A Solution prepared by dissolving 150 c.c. of Sulphuric acid in 450 c.c. of distilled water, cooling and then adding 100 c.c. of Concentrated nitric acid and 300 c.c. of concentrated hydrochloric acid.

titrated with N/10 potassium permanganate, the end point being indicated when two drops give a pink colour. The percentage of Fe_2O_3 is calculated considering that 1 c.c. of N/10 $KMnO_4 = 0\cdot008$ gms. Fe_2O_3.

The percentage of aluminium oxide (Al_2O_3) is calculated by subtracting the percentage of Fe_2O_3 from the percentage of total sesquioxides.

The number of gram mols. per 100 gms. of the soil is calculated by multiplying the percentages with the following factors.

Gm. mols. SiO_2 per 100 gms. soil
= percentage $\times$ 0·0166.

Gm. mols. Fe_2O_3 per 100 gms. soil
= percentage $\times$ 0·0063.

Gm. mols. Al_2O_3 per 100 gms. soil
= percentage $\times$ 0·0098.

The ratio of SiO_2/R_2O_3 is calculated on the basis of gram. mols.

2. *Dispersion coefficient.*—This is defined for any soil as the ratio of the clay percentage dispersed when a soil sample is shaken with pure distilled water to the total clay content (percentage of total clay) in the soil as determined after complete dispersion. In other words it is put down as follows :—

Dispersion coefficient

$$= \frac{\text{Amount of clay before dispersion} \times 100}{\text{Total amount of clay}}.$$

This is determined by the usual International Pipette method of mechanical analysis as modified by Robinson. Only the clay content is required leaving out the coarse sand, fine sand and silt. Therefore, this fraction alone is discussed here.

For the determination of the total clay content, the soil is first dispersed in water. For this, a 2 mm. fraction of the soil is first prepared by grinding the soil with a wooden mallet and passing it through a 2 mm. sieve. This soil sample is then oven-dried at 105°C, cooled in a dessicator and 20 gms. of it are weighed out and placed in a 400 c.c. beaker. 50 c.c. of 3% hydrogen peroxide (technically called 12 vols. perhydrol) is added, the beaker covered with a watch glass and heated on a water bath, care being taken to avoid frothing over. The contents should be agitated frequently at intervals of every fifteen minutes. If much organic matter is present, a further addition of peroxide may be necessary. 20 c.c. of N-hydrochloric acid are now added to break any calcium carbonate, the total volume is made to 100 c.c. and the contents agitated from time to time for nearly half an hour. If much carbonate is present, more acid should be added. Usually 2 c.c. of N-hydrochloric acid for each 1 per cent of calcium carbonate is enough. The beaker is left on the water-bath for nearly an hour after which the contents are transferred to a Buchner funnel to which a filter paper has been fixed. The funnel is fitted to a filter flask and connected with a filter pump (for suction). After the first filtrate has passed through, the soil on the filter paper is washed four or five times with 25–30 c.c. of distilled water, and the filtrate tested with litmus paper free from acid.

The residue on the filter paper is transferred with the help of a blunt spatula by means of a jet of water to a 500 c.c. shaking bottle. 8 c.c. of N-sodium hydroxide solution is added and the bottle is shaken for 5 or 6 hours on a rotary shaker. The contents of the shaking bottle are now transferred to a 1,000 c.c. cylinder (glass stoppered), made up to mark with distilled water and shaken by hand for one minute with repeated inversion and allowed to stand away from sources of heat and out of direct sunlight. Settling is allowed for the time required for clay as given in the chart for different temperatures and then 20 c.c. of the soil solution is pipetted out at a depth of 10 cm., transferred to a weighed dish, dried and weighed, and the amount of clay found and the percentage clay in the soil sample calculated.

Sampling can be done with an ordinary 20 c.c. pipette which is fixed through a wide cork and is so adjusted that when the cork rests on the top of the cylinder, the point of the pipette will be 10 cm. below the surface of the suspension. If the temperature of the soil suspension is 20°C the sampling for clay is done after 8 hours. The time taken to fill the pipette should be about 20 seconds. The contents of the pipette are delivered into a weighed dish (3″ diam.) and evaporated to dryness on a water bath. The dish is then dried to constant weight in an oven at 105°C. If the weight of the dried material is 'W' grams, then 1000W/4 represents the percentage of clay.

The percentage of clay is also determined when the soil is simply shaken with distilled water, in which case 20 gms. of the soil are transferred to a shaking bottle, 300 c.c. of distilled water added, the bottle left over-night and then shaken for 5 or 6 hours and the contents transferred to a 1000 c.c. cylinder as already described. The rest of the method is the same as described above.

The temperature chart for clay sampling is given below :—

Temperature °C	Sampling time hrs.	min.	Temperature °C	Sampling time hrs.	min.
26	6	2	31	4	48
27	5	45	32	4	36
28	5	29	33	4	26
29	5	16			
30	5	2			

3. *Depth of permanent moisture availability.*—This is taken either as the depth of the water table or the elevation from a permanent flowing water level, e.g., a river or stream from which the moisture is likely to flow by capillary action to feed the plant roots. The former index, i.e., the water table, is not always convenient. Therefore the height of the plantation from the permanent flowing water surface in winter is measured by means of a pocket aneroid. When contour-maps are available, as is the case with Nilambur forest division, this height could easily be read off from the available maps.

4. *Aspect.*—This is the direction taken by bearing at right angles to the feature, e.g., a slope facing north, has a northern aspect, while a slope facing south has a southern aspect.

APPARATUS—CHEMICALS NEEDED

Apparatus

1. A fume-cupboard (glass case with chimney) 6′×3′×4′ (To be locally set up).
2. Chemical balance.................One.
3. Weight box with weights 100 gms. to 0·001 gm., complete with rider....Two.
4. A sieve set with 2 mm., 1 mm. holes, 50 mesh, 100 mesh. with cover and bottom diameter of rim 8″............One set.
5. Sieves 70 mesh with 0·2 mm. holes for I.M.M..........................Six.
6. A nickel dish with counterpoise weight for weighing out...................Two.
7. Air-oven with perforeted shelf with stand, size 12″×12″×9″................One.
8. (*a*) Shaking machine for 6 bottles, Prof. Wangner's type with bottles..One.
   (*b*) Extra bottles for the above....Six.
9. Hot air motor 1/16 H.P. for the above ....One.
10. (*a*) Stoves, large size (about the size of Primus No. 100, or some other make)..................Three.
    (*b*) Stoves, small size (about the size of Primus No. 96)..............Six.
11. Still, for manufacturing distilled water, worked with stove...............One.
12. Spirit burners, complete with spirit can and tubing....................Three.
13. (*a*) Tripod stands, 9″ high..........Six.
    (*b*) Tripod stands, 7″ high..........Six.
14. Wire-gauze with asbestos centre.....One dozen.
15. Pair of tongs, brass..............Three.
16. Water-bath with four openings, with sets of rings...................Two.
17. Filter pump, matallic.............Two.
18. (*a*) Pestle and mortar (porclain), diam. 6″ ....One.
    (*b*) Pestle and mortar (porclain), diam. 4″ ....One.
19. Dessicator, 8″ diameter............Two.
20. Beakers, sigcol glass 1000 c.c.......Four.
    Beakers, sigcol glass 500 c.c.........Six.
    Beakers sigcol glass 400 c.c. (squat) ....Eight.
    Beakers sigcol glass 400 c.c. (tall) ....Eight.
    Beakers sigcol glass 300 c.c. (squat) ....Twelve.
21. Buchner funnels (porclain) 3″ diameter ....Six.
22. Dishes, porclain, unglazed from outside, size 5″ diameter................Six.

Dishes, porclain, unglazed from outside, size 3″ diameter............One dozen.

23. (*a*) Filter flasks 1000 c.c...........Six.
(*b*) Graduated flasks 1000 c.c., 500 c.c. and 100 c.c.........Four of each.
(*c*) Flasks, sigcol glass, 1000 c.c., 500 c.c., 300 c.c...........Six of each.

24. Graduated cylinder, glass stoppered, one litre capacity....................Six.

25. Graduated cylinder, with spout 100 c.c. capacity.......................Four.
Graduated cylinder, with spout 25 c.c. capacity.......................Four.
Graduated cylinder, with spout 10 c.c. capacity.......................Four.

26. Burettes with glass stopcocks, 50 c.c. ....Three.

27. Pipettes 50 c.c. capacity	..	Three.
,, 25 c.c. ,,	..	Four.
,, 20 c.c. ,,	..	Four.
,, 10 c.c. ,,	..	Four.
,, 5 c.c. ,,	..	Four.
28. Funnels 6″ diameter	..	Four.
,, 3″ ,,	..	Eight.

29. Crucibles with lid, 20 c.c. capacity.... ....Eight.
Crucibles with lid, 10 c.c. capacity.... ....Twelve.

30. Filter paper, Whatman No. 50 cut 9 cm. ....Two packets.
Filter paper, Whatman No. 40 cut 9 cm. ....Two packets.
Filter paper, sheets.........100 sheets.

31. Sand baths, thick plate........Twelve.

32. Watch glasses 8·5 cm. diameter ....Twelve.

33. Thermometers, centigrade, to read up to 200° C.........................Two.

34. Camel hair brushes................Six.

35. Glazed paper.........One dozen sheets.

36. Rubber tubing, rubbercorks, assorted ....Required amount.

37. Velvet, corks, assorted.......One gross.

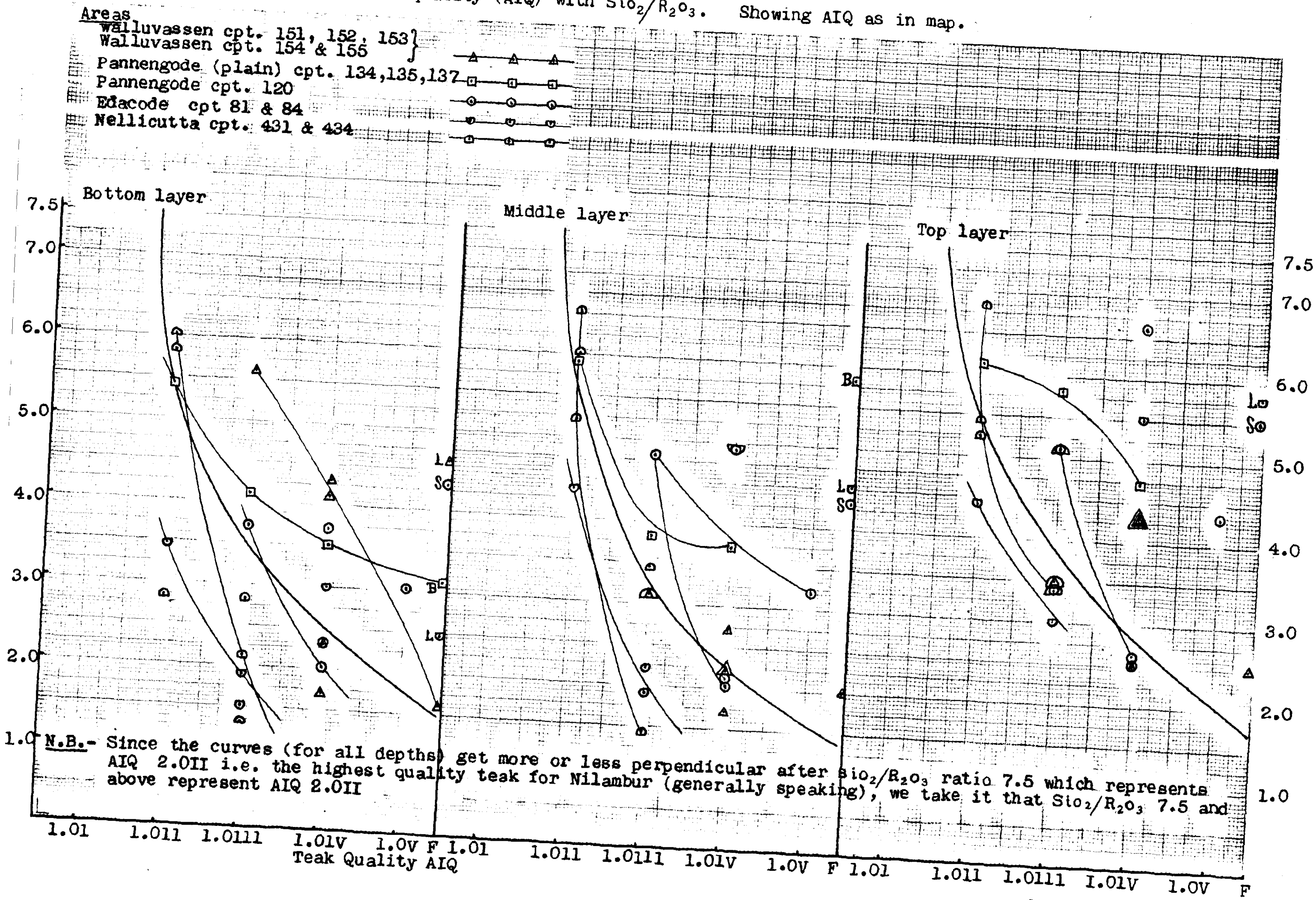
Chemicals

1.	Acid sulphuric, concentrated, pure		10 lb.
2.	,, hydrochloric, ,, ,,		8 ,,
3.	,, nitric, ,, ,,		8 ,,
4.	,, sulphuric, concentrated, commercial	..	2 ,,
5.	,, hydrochloric, concentrated commercial	..	2 ,,
6.	,, nitric, concentrated, commercial	..	2 ,,
7.	Ammonium chloride, pure	..	1 ,,
8.	Ammonia, liquor, Fort pure	..	2 ,,
9.	Ammonium thio-cyanate, pure	..	1 ,,
10.	Barium chloride, pure	..	1 ,,
11.	Silver nitrate, pure	..	4 oz.
12.	Potassium permanganate, pure	..	1 lb.

13. Hydrogen per oxide 12 vols. (3%) Six bottles of 2 oz. each or 6 × 20 oz.

14. Litmus paper books, red and blue, 1 dozen books for each.

Curves relating teak quality (AIQ) with SiO_2/R_2O_3. Showing AIQ as in map.



N.B.- Since the curves (for all depths) get more or less perpendicular after SiO_2/R_2O_3 ratio 7.5 which represents AIQ 2.0II i.e. the highest quality teak for Nilambur (generally speaking), we take it that SiO_2/R_2O_3 7.5 and above represent AIQ 2.0II

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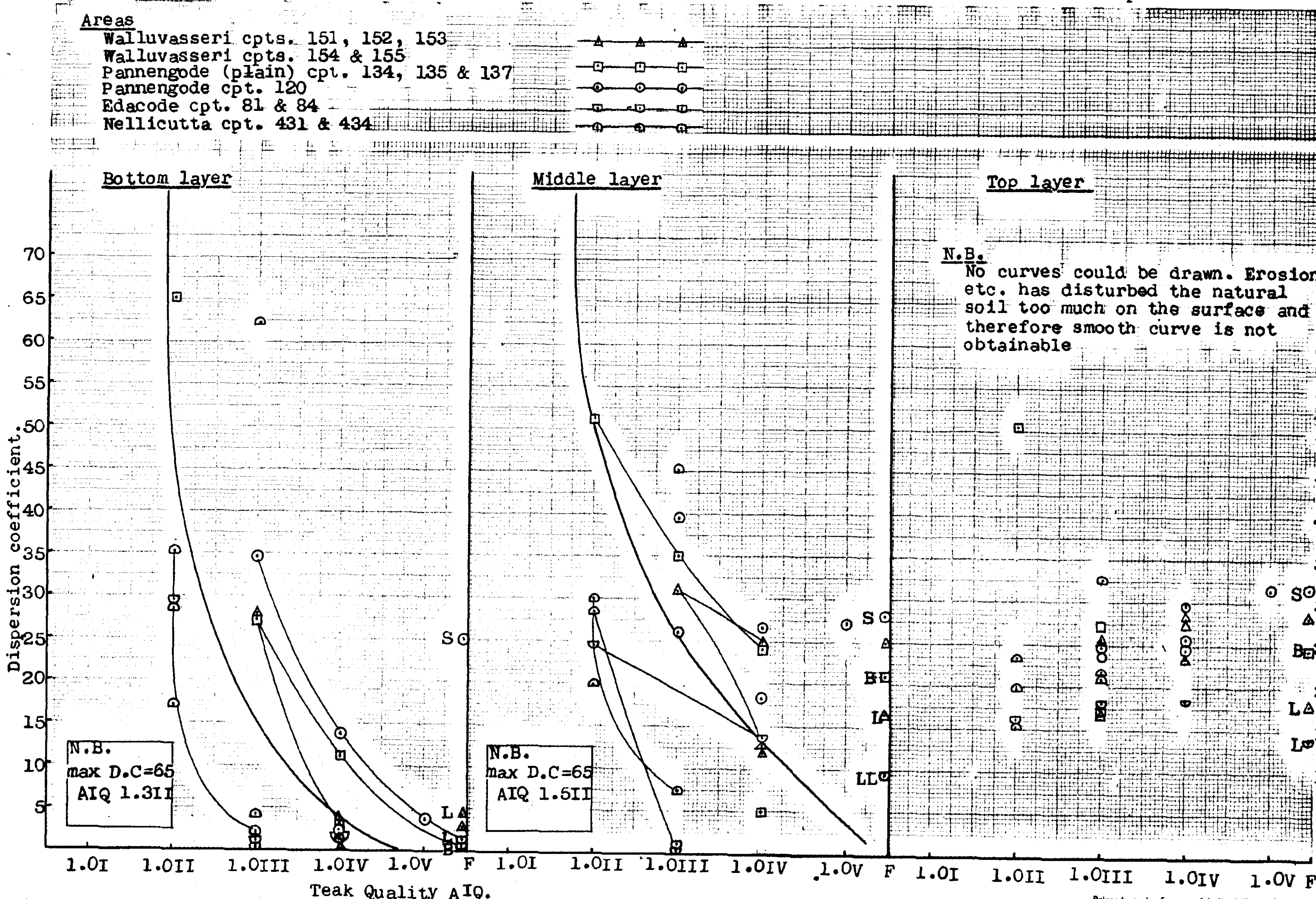
Reg. No. 2752 X. D. D. (c) 934'50.

Curves relating teak quality (AIQ) with Dispersion coefficient. AIQ shown as in map.



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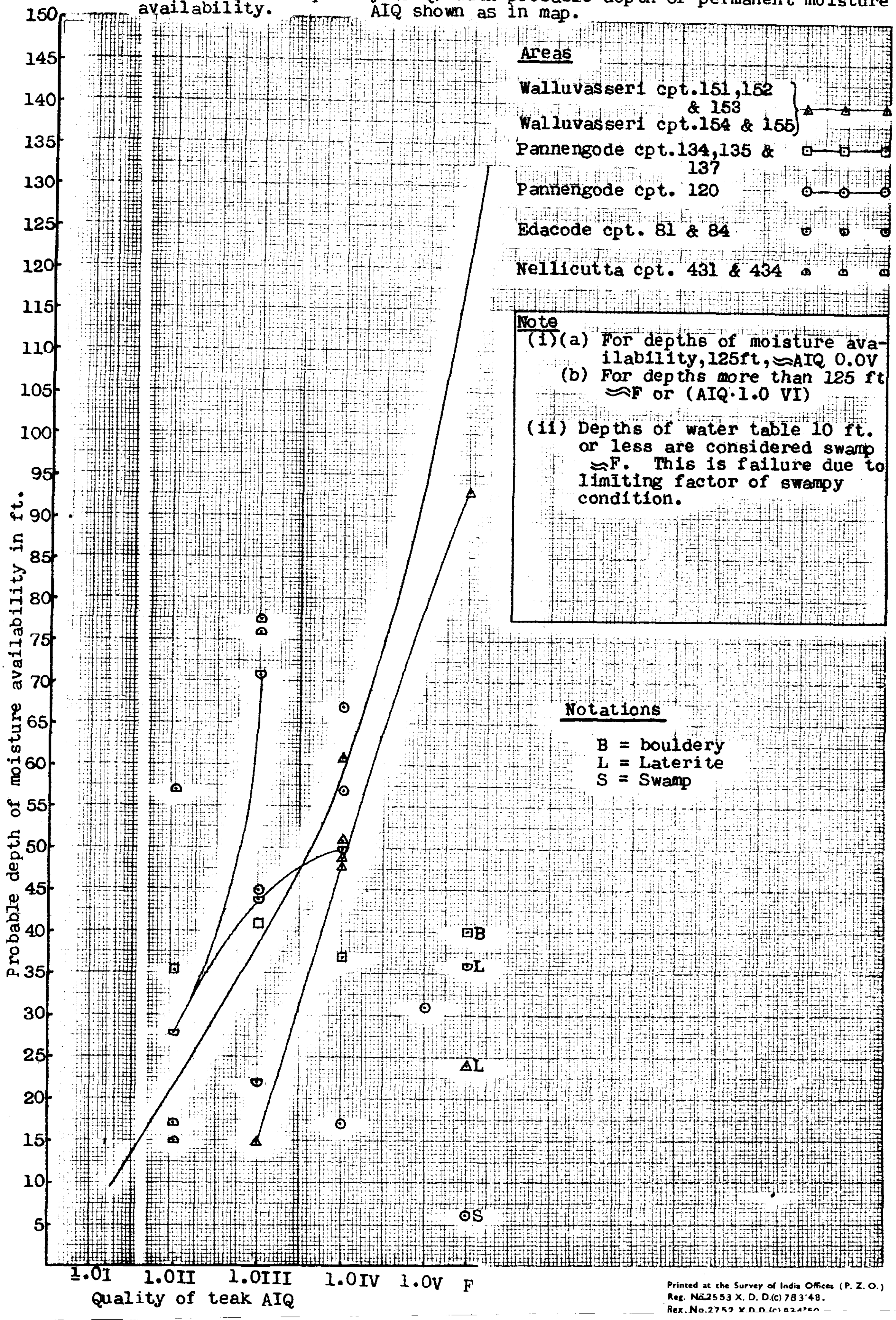
Reg. No 2752 X.D. D.(C) 934'50

Curves relating teak quality (AIQ) with probable depth of permanent moisture availability. AIQ shown as in map.



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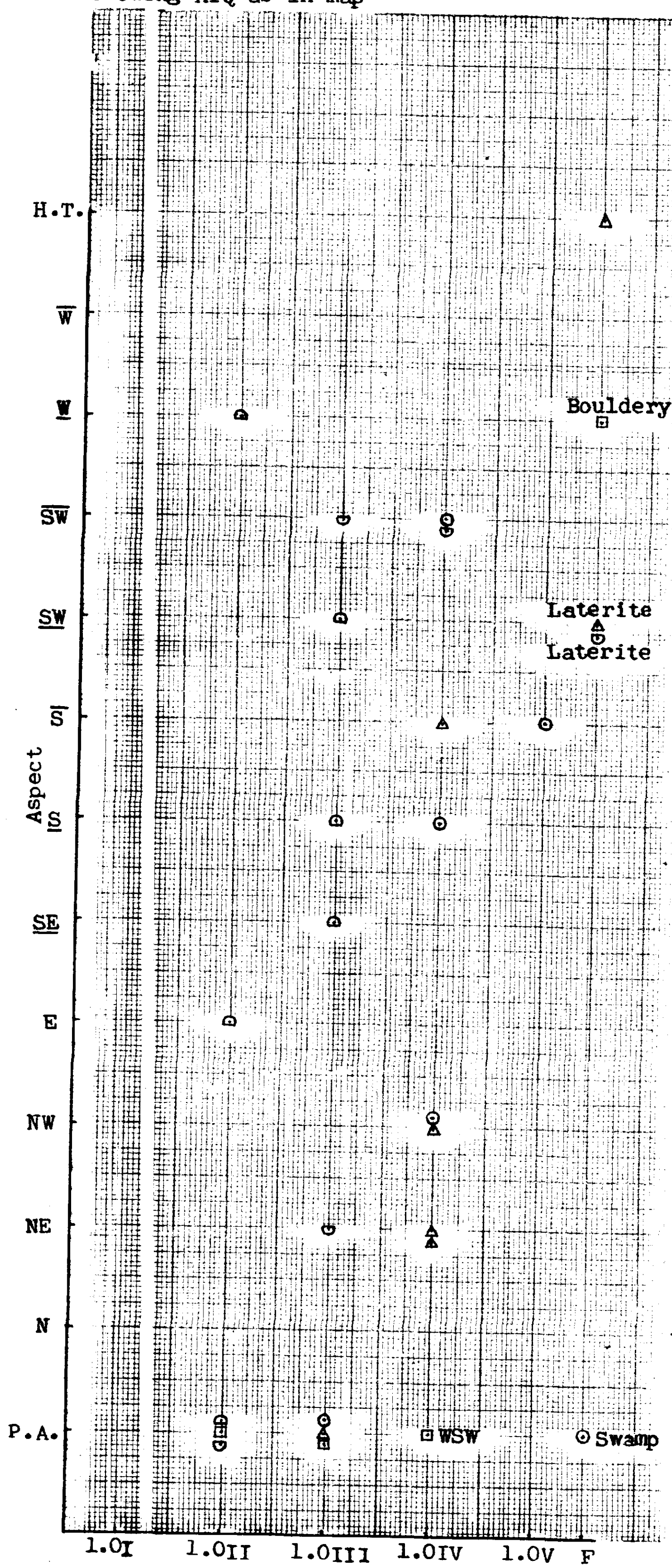
Rex. No.2752 X.D.D.(c) 934'50

Teak quality as related to aspect
showing AIQ as in map



Notations

Plain alluvium	P.A.
Northerly	N
North Easterly	NE
North Westerly	NW
Easterly	E
South Easterly	SE
Southerly(near foot hill)	$\underline{S}$
Southerly(near hill top)	$\overline{S}$
South Westerly (near foot hill)	$\underline{SW}$
South Westerly (near hill top)	$\overline{SW}$
Westerly(near foot hill)	$\underline{W}$
Westerly(near hill top)	$\overline{W}$
Hill top	HT

Areas(plantations)

Walluvasseri cpt. 151, 152,153	△
" cpt. 154,155	▲
Pannengode cpt. 134, 135, 137	⊡
Pannengode cpt. 120	⊙
Edacode cpt. 81 & 84	⊍
Nellicutta cpt. 431 & 434	⌂

Analysis

AIQ

I Nil

II PA(3), E(1), $\underline{W}$(1)

III PA(3), $\overline{NE}$(1), SE(1), $\underline{SW}$(1), $\overline{SW}$(1), $\underline{S}$(1)

IV NE(2), NW(2), $\overline{SW}$(2), SWS(1), $\underline{S}$(1), $\overline{S}$(1)

V S(1)

F SW(2), PA(1), W(1), HT(1)
Laterite Swamp Bouldery

Rules for assessing AIQ an aspect basis

Aspect	AIQ
PA (any aspect), foot hill & N	II
NE, E, $\underline{W}$, $\underline{SW}$, $\underline{S}$, $\underline{SE}$	III
NW, $\overline{NE}$, $\overline{E}$, $\overline{NW}$, $\overline{W}$	IV
$\overline{S}$, $\overline{SW}$, $\overline{SE}$	V
With limiting factors as laterite, swamp, bouldery and H.T.	F

Note

(i) Near foot hill ≈ About 50 ft. above foot hill(running water)
Near hill top ≈ About 50 ft. below hill top.

(ii) For low hills $\overline{S}$, $\overline{SW}$ & $\overline{W}$(&HT) are taken to be $\underline{S}$?$\underline{SW}$ & $\underline{W}$(&$\underline{S}$)

Printed at the Survey of India Offices (P. Z. O.)
Reg. No.2553 X. D. D. (c) 783'48.

CARE OF ELEPHANTS

BY M. D. CHATURVEDI, I.F.S.
(*Chief Conservator of Forests, U.P.*)

SUMMARY

Atomized kerosene has proved far more effective in dealing with maggots in wounds of animals than chemicals. While oil soothes the wound and stifles maggots to death, chemicals kill the living tissue far more than maggots.

Mauled twice by a tiger, one of our elephants developed wounds which defied all treatment for several weeks. These wounds were those which escaped attention when first aid was rendered to the elephant and all marks of injury by tooth and claw were treated with permanganate crystals. While permanganated wounds cured themselves within a week, those left untreated soon festered and developed maggots. A wick soaked in 10 per cent mercuro chrome solution inserted in the wound brought forth morning after morning a few dead maggots and a lot of pus. The chemical used never reached the innermost tissues which harboured them. It killed the living tissue far more than the maggots. Both the size of the wound and the number of maggots kept on increasing.

2. Exasperated at this state of affairs, I examined the anatomy of the maggot. Its breathing mechanism offered a vulnerable point of attack. I sent for my flit pump. No sooner did the atomized oil reach the innermost recesses of the wound, maggots walked out in a procession while I watched. The wounds were thereafter plugged with cotton-wool. The following morning, a large number of maggots were found dead at the end of the cotton swab. Wounds free of maggots cured within a week.

3. Ordinary kerosene was tried in dealing with maggots in hoofs of buffaloes and in a ghastly wound of a donkey with telling effect. The secret of success lies in the atomization of oil which clogs the breathing mechanism of maggots inside a wound.

PROGRESS OF FOREST PATHOLOGY IN INDIA DURING THE QUINQUENNIUM* 1944–49

BY K. BAGCHEE

The period is one of transition from the special wartime commitments to normal peacetime work which, however, is very different from the pre-war projects. During war, timber and timber protection appeared to be matters of prior importance, more attention therefore being given to checking timber for war purposes. Advisory work for the Timber Supply Directorate was also undertaken. Inspection of timber depots all over the country for decay due to fungi, and examination of the felling coupes to trace origin of the fungi in the virgin forests resulted in the accumulation of a large amount of data on wood-decaying Hymenomycetes and records of new fungi on various timber trees. Investigation on the morphology, biology and pathology of these fungi are being carried out in details the work being included in peacetime projects. Another study begun during war and continued to peacetime is the study of Indian Dry-rot fungi, some of the results of which are now being published.

A large collection of wood destroying fungi, their cultures and specimens showing decay were handled from day to day during wartime. These specimens and cultures are being indentified in the laboratory, some with the help of the workers abroad. The nucleus of culture collection of forest fungi was a direct outcome of this development and now a collection of 300 spp. of wood-decaying fungi is maintained, about 100 spp. of which are fungi pathogenic to fresh trees with strains and duplicates.

Fungi were indentified and incorporated in the herbarium and materials illustrating the types of decay in the wood are exhibited in the museum. There are about 6,000 specimens of wood-rotting Hymenomycetes in the herbarium with a large number of duplicates consisting of different forms, strains, etc., according to host and habitat, and about 700 exhibits in the museum. Besides these there are about 800 microfungi, including rusts, leaf spots and blights of trees, collected mostly from virgin forests during routine pathological surveys, to be worked out.

About 300 spp. of humus and soil Agarics and Gasteromycetes of coniferous forests and about 750 spp. of microfungi, rusts, needle casts and leaf disease fungi are also included in the list of unidentified material.

Photographs illustrating the habitat and pathology of forest fungi and coloured drawings are maintained for the purposes of research and publication, an average of 250 photographs and 50 coloured illustrations being added to the collection every year.

The Mycologist attended the 5th Commonwealth Mycological Conference in London as the leader of the Indian delegation and also represented India at the meeting of the British Association at Brighton in 1948. After these meetings he visited various mycological and botanical institutes and laboratories and contacted over 75 well-known workers in the field of mycology and plant pathology, also the industrial mycologists in the fermentation laboratories. The outcome of this large scale contact with workers can be seen in greater co-ordination of work in forest mycology and forest and timber pathology. An exchange connection also was established with the workers of different countries during the Mycologist's visits to U.K., Europe, U.S.A. and Canada, and a large number of forest fungi from abroad was procured. Limited copies of the report of this deputation are available for distribution.

I. STUDY OF INDIAN WOOD DESTROYING FUNGI

The investigations on the wood-rotting fungi are divided into six projects although some of them merge into one another or overlap, the results of one experiment being useful for another, or the data of one project being utilized for the other.

1. *Standardization of Wood-rotting Fungi.*—To ascertain the destructive action of wood destroying Hymenomycetes, decay tests on 158 fungi were completed during this period.

* Based on the report prepared for the meetings of Indian Agricultural Research Council, Crop and Soils Wing, on 27th–29th March 1950 held at Patiala, PEPSU.

Fungi on conifers were tested on *chir* wood-blocks and those on hardwoods on sal wood-blocks, for a period of twelve months. A large number of fungi besides these were studied with reference to their morphology, host, distribution, biology and pathology.

To classify fungi causing white rots and brown rots, oxidase reactions on malt agar containing 0·5% or ·3% tannic acid were successfully carried out. Fungi were tested on malt agar containing 0·007% Gentian violet as indicator to distinguish white rots from brown rots. Investigations on the wound parasites of hardwoods and conifers have been conducted from the morphological, biological and pathological point of view. This work has been divided for the purposes of publication into 3 parts, the first part dealing with 7 fungi being completed and sent to the press.

2. *Investigations on the natural resistance to decay.*—This project has been introduced recently as a co-ordinated scheme to prepare a schedule of the durability of various kinds of timber in the Commonwealth after testing them against a few common decay organisms specific to them. The timbers are to be graded as most resistant, moderately resitant, resistant, moderately susceptible, and highly susceptible to fungus decay. The other countries interested in similar work are U.K. and Australia. The timbers from India to be examined in the first instance are teak, sal, chir (*Pinus longifolia* Roxb.) and deodar (*Cedrus deodara* Loud.).

The popular gradations of timber in the market into most resistant and highly susceptible ones with various intergrades will be verified in the laboratory by using decay tests, while simple lab ratory methods will be evolved to ascertain in a short period, the natural durability of a timber in service.

3. *Investigations on the dry-rot fungi.*—Fungi causing decay in hardwood and conifers in service or in storage are considered under this project. As already pointed out, this project is the outcome of advisory service during war when various government timber depots in the North India were inspected and material used for vital war work was checked. Five spp. of *Lenzites,* two spp. of *Merulius* and six spp. of *Poria* on conifers have been investigated during this period. On the hardwood spp. three spp. of *Trametes* and five spp. of *Poria* on sal are under examination. Cultural studies of a large number of fungi collected from the Himalayan forests which are likely to become dry-rot in timber in service, are being investigated in the same way as the standardization tests described above. A paper dealing with five spp. of *Lenzites* producing dry-rot is under preparation.

4. *Study of bamboo rotting fungi.*—Serious damage is done to bamboos in storage by many fungi. Besided being used as timber for construction of houses, huts, etc., the bamboo is an important source of pulp ; and unless protected by preservatives and hygienically stored, sap-stain and decay cause a serious loss to the raw material. The bamboo fungi have been studied from the pathological as well as the decay point of view. A preliminary account of bamboo fungi has been written, detailed examination being in progress. A wood-rotting test with 8 fungi was carried out.

5. *Taxonomic Studies of Poria and Thelephoraceae.*—These fungi contribute to a large number of timber decaying species. Except some ground work, no taxonomic work on the wood-decaying *Poria* and *Thelephora* has been done in India. This is due to a paucity of literature and authentic specimens in this country. But this difficulty could be overcome with help from abroad. Already a quantity of literature and specimens have been received by the mycological herbarium, F.R.I., from Sweedish, Canadian and American workers. It will be possible now to conduct taxonomic work on these families.

6. *Toxicity Tests.*—In order to find out the efficacy of preservatives prepared from indigenous materials by the Composite Wood and Wood Preservation Branch of the Institute, large scale tests were conducted with sal sap-woodblocks treated with various concentrations, these being tested for a period of 4 months. The following preservatives were tested in different concentrations during the period.—

1. Copper salts of *Bassia latifolia* Roxb. oil.
2. Creosote.
3. B.O.C. oil.
4. Hardy and Phenyl-mercury fixtan.
5. Tests with various strengths of sodium pentacholorophenol have been taken up.
6. Cashew nut oil. (Ref. Pathological Notes No. 4. Laboratory tests of

Cashew nut oil as wood preservative—Ind. For., April 1950).

II. THE STUDY OF PARASITIC DISEASES OF FOREST TREES

Some of the common well-known diseases of trees which although not of widespread nature, cause serious loss to trees in their natural habitat or outside their habitat where they are introduced to serve some useful purpose, have been considered under this project ; wound parasites and root fungi being dealt with. Morphology and pathology of the fungi have been considered in detail and various aspects of protection discussed. For the sake of convenience the project has been divided into three sections.

1. *Investigation on sal diseases : Gauj fungus and its associates.*—The unsoundness of sal due to 'Gauj' is wide spread covering 36 divisions in five provinces (Figs. 1, 2 & 3). After an extensive search the sporophores of the 'Gauj' fungus have been found. 'Gauj' has been identified as *Fomes caryophylli* (Rac.) Bres. Inoculation experiments to prove pathogenecity of the fungus have been conducted. Identity of 'Gauj' from related fungi like *Fomes rimosus* Berk. and *Fomes badius* Berk. on cultural character were attempted.

Fomes caryophylli has also been recorded on *Anogeissus latifolia*, Wall. *Cleistanthus collinus* Benth., *Syzygium cumini* (Linn.) Skeds. and *Madhuca latifolia* Macbridge.

About 150 fungi have been listed on sal causing various diseases in the living trees and rots in the worked timber. The pathology of eight fungi with their predisposing factors have been worked out by inoculation experiments and suggestions for control are based on crop improvement, admixtures of species, selection of species, selective felling, etc., for minimizing the damage caused by their attack. All the field observations and laboratory data are being incorporated in a paper on the diseases of sal, which is under preparation.

2. *Diseases of common hardwood trees of North India.*—Under this are dealt some important wound parasites which attack avenue and shade trees and also trees in the forest. Details of biology and pathology of the fungi have been described and the methods of control suggested. (Ref. Fungi as Wound Parasites on Indian Trees—in the press).

3. *Diseases of conifers in the Himalayas.*—*Fomes annosus* Fr., *Armillaria mellea* (Vahl.), Quelf., *Fomes pini* (Thore.) Llyd. *Fomes pinicola* Fr., *Polyporus circinatus* Fr., *Polyporus schweinitzii* Fr. and *Poria* sp. attacking conifers in the hills are investigated under this section.

4. *Principal parasites of oaks in India.*—Several Polypores and Thelephores which enter through wounds (fire-scars, lopping, blazing wounds, etc.) are being considered in this section.

5. *Studies of Wilt and Die-back.*—(a) *Shisham, khair, babul, etc., in the taungyas.*—A paper on wilt and die-back of shisham, babul and khair in the artificial regeneration under the agriculture-cum-forestry management has been published.

(Ref. Pathological Notes No. 2, Ind. For., Vol. LXXI, pp. 20–24, 1945).

(b) *Diseases of Casuarina.*—(Fig. 4) Examination of diseased specimens received from various districts of Orissa and Madras was conducted for many years as routine examination but did not give any definite clue to the causes of mortality although various types of fungi were isolated from these materials. To get first hand information regarding diseases of Casuarina in eight districts of Madras presidency where extensive mortality was reported, the mycologist recently made a tour to these areas and collected a large number of samples from different localities and a detailed investigation has been taken up. A paper on the mortality of Casuarina due to *Trichosporium vesiculosum* Butler has been published in the Current Science, Vol. 19, No. 2, Feb. 1950. pp. 63–64 (Wilt of Casuarina by D. Marudarajan, T. S. Ramkrishnan, C. K. Soumini).

(c) *Mortality of Evodia roxburghiana.*—Failure of Evodia (Fig. 5) in 400 acres of plantation in the Kannoth Range, Wynaad Division, Malabar, has been taken up and a large number of specimens of root and stump having been examined. A virus disease is suspected, but definite proof is awaited.

(d) *Mortality of wattle plants.*—The seedling disease of *Acacia mollissima* Willd. from the the Bombay Presidency has been investigated.

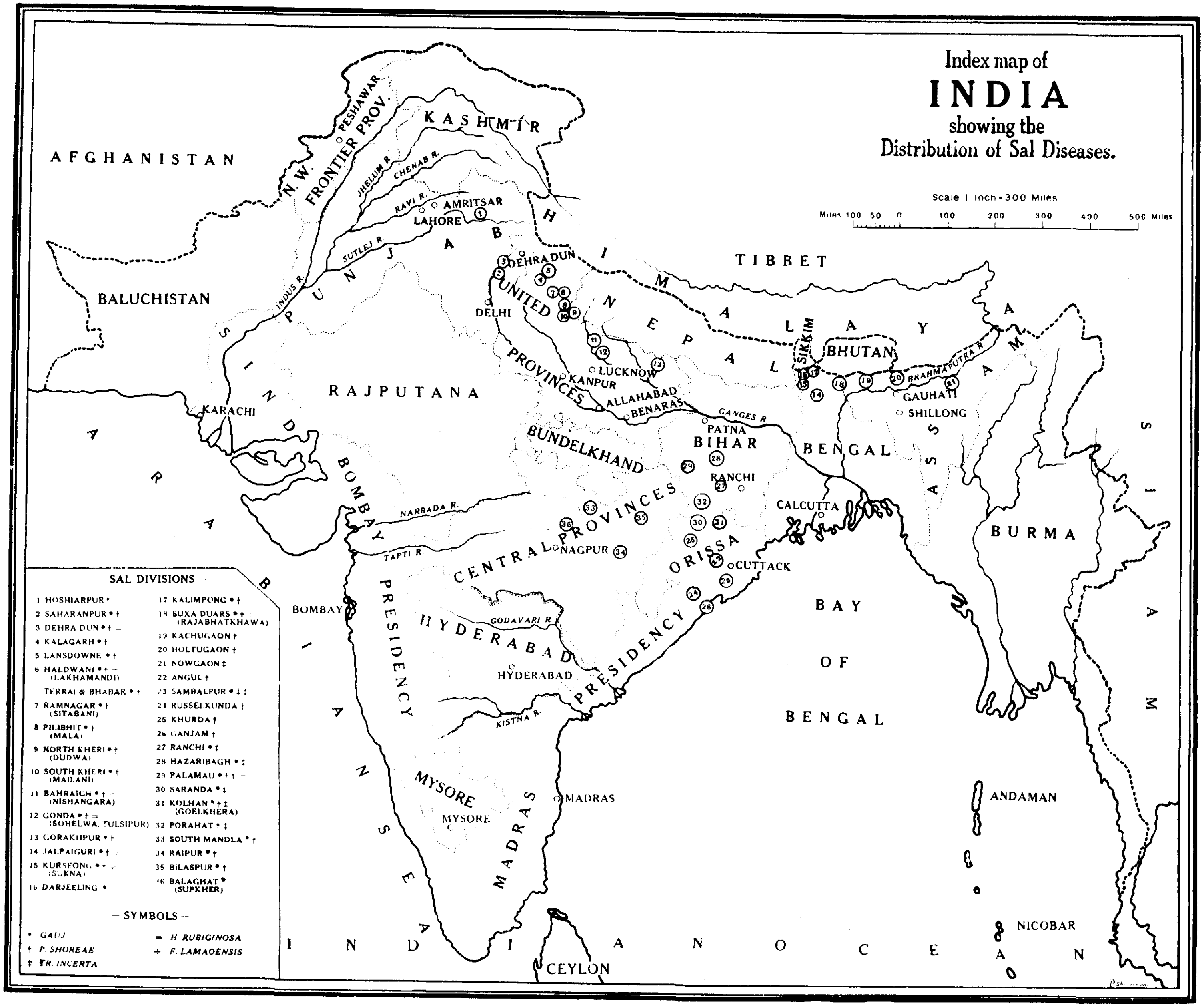


FIG. 1.—Index map of India showing the distribution of sal diseases.

FIG. 2.—The sal (*Shorea robusta*) Gaertn. in Supkhar range, Balaghat division C.P. The regeneration in the foreground beaten down by frost annually becomes susceptible to the attack of *gauj* (*Fomes caryophylli* Rac.) Bres. Note the "Lombardy Poplar" appearence of the advanced trees and the "feathering out" of the epicormic branches of sapling which are the symptoms of the disease at the initial stages as the fungus enters into the living tissues. The fungus migrates into the heartwood, as the trees pass on to maturity and establishes itself as heartrot.

FIG. 3

→

Eyes (punk-knots), probably the surest symptom of *gauj* (*Fomes caryophlli* Rac. Bres.) disease, appear later on, stare at forest officers and contractors who know such trees are likely to yield but little revenue.

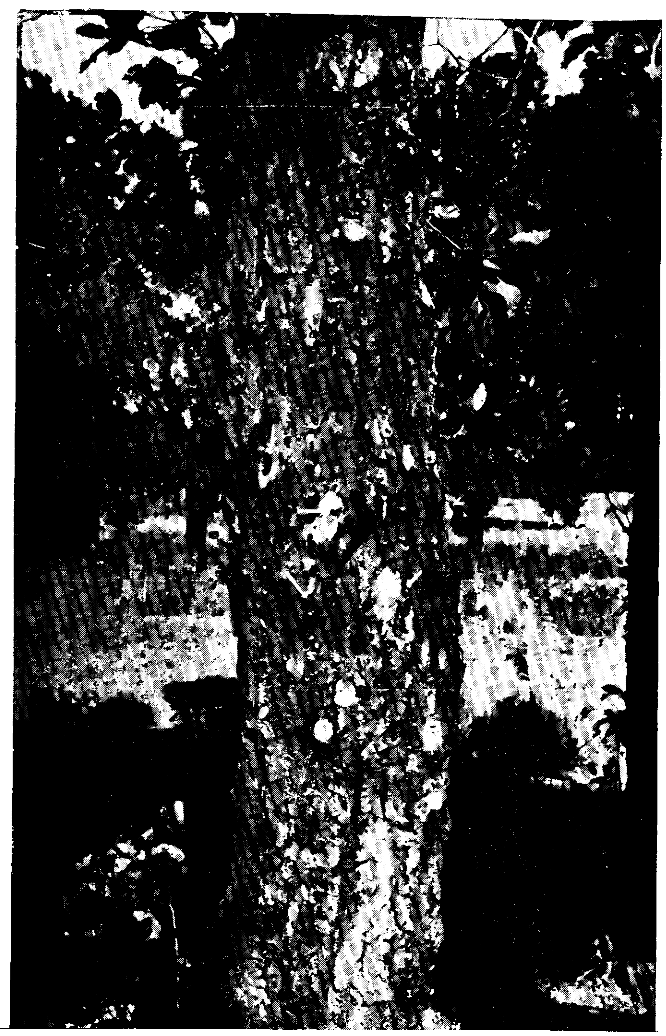


FIG. 4

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Casuarina equisetifolia Blanco. killed by *Trichosporium vesiculosum* Butler, in Kothachenu plantation, Sriharikota range, Nellore district, Madras.

FIG. 5.—The mortality of *Evodia roxburghiana* Benth. in the plantations, Kanoth range, Wynaad district, Madras. Note the dead trees in lines flanking the hill-side. The disease in course of 2 to 3 years has opened out the forest and in course of 5 to 6

FIG. 6.—Deodar (*Cedrus deodara* Loud.) Khadra nursery, Bawar range, Chakrata division, U.P. Two years seedlings are being checked for the natural infection of *Peridermium cedri* (Barcl.) Sacc. before transplantation. Autoecism of this destructive rust has been proved by direct inoculation of aeciospores.

FIG. 7

←

A young deodar (*Cedrus deodara* Loud.) inoculated in June 1934 by aeciospores in Kathian, Bawar range, Chakrata division, U.P. and photographed in 1947. Note that the tree has been transformed to a completely "witches' broom", the disease having spread from one branch to another. Although the infection by aeciospores has been proved the possibility of having an alternate stage has not been waved out. A few probable hosts have been considered for cross-inoculation experiments.

FIG. 8.—*Peridermium cerebrum* Peck. (*Cronartum quercuum* Berk.) Miyabe on Khasi pine (*Pinus insularis* Endl.) in Shillong range, Assam. The fungus is both autoecious and heteroecious. Note the number of galls on the stems of the pine. The heteroecious character has been proved by inoculation experiments with aeciospores from Shillong on seedlings of oak in Dehra Dun. The autoecism has been proved in U.S.A., China and Japan.

FIG. 9.—The pines of Shillong range are in a moribund state and the whole plantation is threatened with destruction. Note the alternate host, the oak (*Quercus griffithii* Hk. f. & T.) is mixed with the pine. The shrivelled up leaves of oak bear innumerable telialsori of this destructive rust.

FIG. 10.—Leaves of *Quercus griffithii* Hk. f. & T. bearing innumerable telialsori of (*Cronartium quercuum* Berk.).

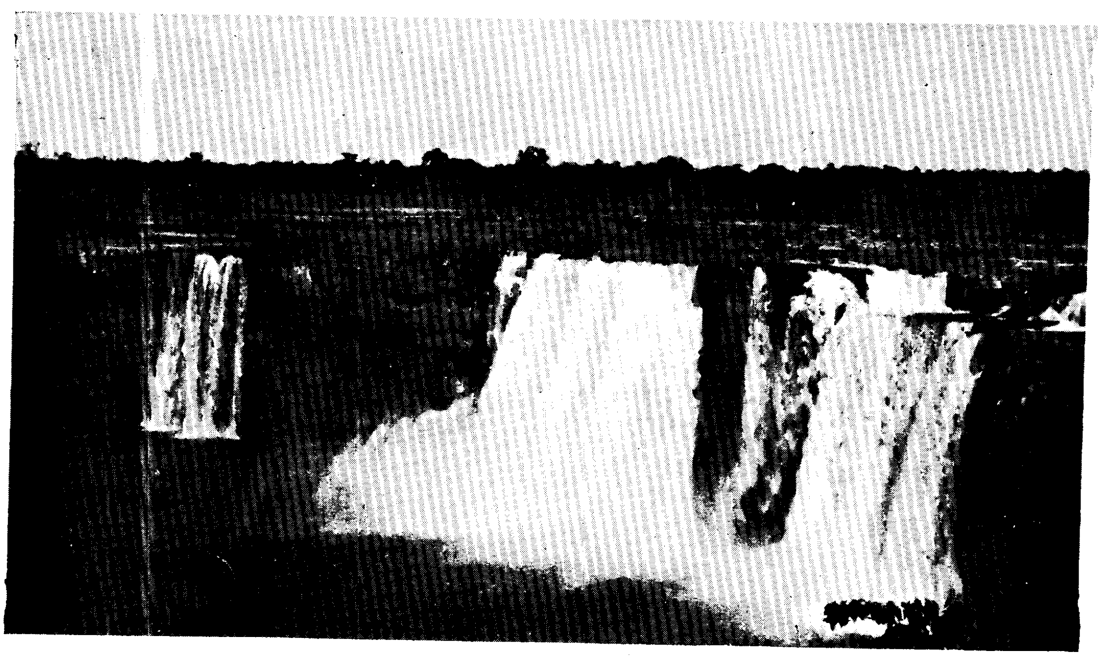


FIG. 11.—Indravati (Chittrakut waterfall) on way to Dantewara, South Bastar division, C.P. The sal disease survey was conducted in this region, where sal grows in association with teak and other deciduous hardwoods.

FIG. 12

→

Tirathgarh waterfall, Kanger range, North Bastar division, C.P. showing the mixed deciduous forests of sal, teak salai, etc., on the banks of stream.

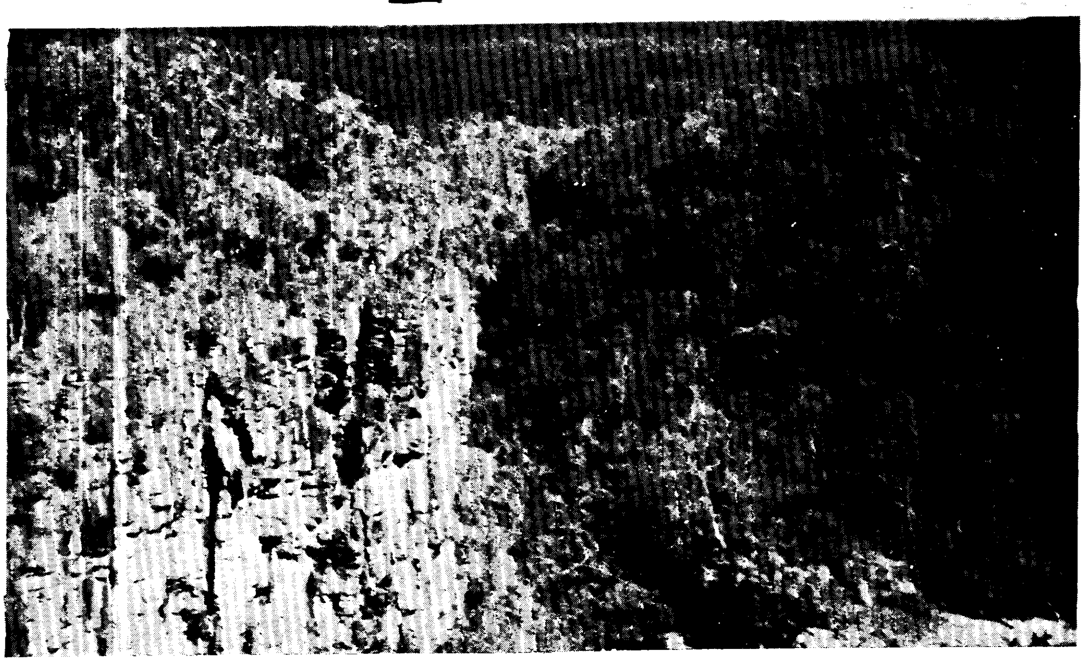


FIG. 13.—The Kanger reserve facing Tirathgarh waterfall, North Bastar division, C.P. Sal grows as pure crop in the pockets along the banks of Kanger nalla (the dark patch of vegetation in the foreground) and mixed with teak (*Tectona grandis* Linn.), salai (*Boswellia serrata* Roxb.), and other deciduous hardwood species (the lighter

The seeds received from Kanays (Africa) were healthy. Of the six fungi were isolated from the diseased plants, one found to be highly pathogenic, two weakly and the rest non-pathogenic. An investigation of the gummossis disease of wattles in the Nilgiris is under contemplation.

(e) *Canker and blights of hardwoods in the plantations.*—A new canker disease of teak has been recorded and identified. (Pathological Notes No. 3, Ind. For., Vol. 73, pp. 332–334, July 1947).

III. INVESTIGATIONS ON THE RUST PARASITES OF CONIFERS AND OTHER NEEDLE CAST FUNGI

The biology of the stem and needles rusts *Cronartium himalayense* Bagchee and *Coleosporium* of *Pinus longifolia* Roxb. was completed in the previous quinquennium. (Pathological Notes No. 1, Ind. For., Vol. LXX, pp. 323–325, Oct. 1944). In the present period the biology of the stem and needle rusts of *Pinus excelsa* Wall. has been worked out.

2. The stem rust has been confirmed as *Cronartium ribicola* Fischer the alternate host being *Ribes rubrum* Linn. and *Ribes nigrum* Linn. The fungus is comparable morphologically and physiologically to *Cronatium ribicola*. The needle rust of *Pinus excelsa* which was previously known as *Peridermium brevius* (Bracl.) Sacc., has been described as *Coleosporium barclayense*, the alternate host being *Senecio rufinervis* DC. with two physiological forms extending in the same region. A new lepto-form microcyclic rust on *Pinus excelsa* has been described as *Melampsora oblonga* (ref. Contributions to our Knowledge of the Morphology, Cytology and Biology of Indian Coniferous Rusts. Part II.—Observations on the occurrences of *Cronartium ribicola* Fischer and *Peridermium indicum* Colley and Tayler on *Pinus excelsa* Wall. with reference to their distribution, pathology, inoculation experiments and comparative morphology, Ind. For. Rec. (new series) Botany, Vol. IV, No. 1.

(Ref. Contribution to our Knowledge of the Morphology, Cytology and Biology of Indian Coniferous Rusts. Part III.—The Biology of *Peridermium brevius* (Barc.) Sacc. (*Coleosporium barclavense* n. sp. on *Senecio rufinervis* DC.) and *Melampsora oblonga* n. sp. on the needles of *Pinus excelsa* Wall. Ind. For. Rec. (new series) Botany, Vol. IV, No. 2.

3. The autoecism of *Peridermium cedri* (Barcl.) Sacc. the destructive rust of deodar (*Cedrus deodara*) (Fig. 6) has been proved by inoculation experiments (Fig. 7) but the possibility of its also being a heterœcious sp. remains. Several Melampsoraceous rusts were considered for the probable alternate stage but cross inoculations conducted to connect them have failed. It is proposed to conduct a search for the occurrence of *Melampsorella caryphyllacearum* (Link.) Schrœt. which is likely to be the alternate stage on *Cerastium vulgatum* Linn. and *Stellaria paniculata* Pall. in the Himalayas, and to carry out inoculation experiments on these hosts.

4. The injurious gall forming rust on *Pinus insularis* Linn. (Figs. 8 and 9) of Shillong range, Assam, has been identified as *Peridermium cerebrum* Peck. The alternate stage *Cronartium quercuum* (Berk.) Miyabe on *Quercus griffithii* Hook., f. and Thom. which was found in the vicinity was reproduced by inoculation experiments on *Quercus griffithii* (Fig. 10).

5. Two new rusts in the æcial stage on the needles of *Abies pindrow* have been discovered. Morphologically, i.e., from the character of pycnia and æcia on the conifer, one appears to be an *Uredinopsis* and the other *Milessia*, both having the alternate stages on ferns. Only one form has been worked out and connected with an unrecorded *Uredinopsis* on *Aspledium* sp.

6. An examination of a collection of Himalayan rusts was done in the biological laboratory of the Harvard University, with Prof. J. H. Faull, Prof. Emeritus, Harvard University and 5 new species were recorded out of 27 rusts. Ninety-five specimens from the herbarium were taken out and studied by Dr. M. Das under Mr. E. W. Mason in the Commonwealth Mycological Institute, New England. A collection of 17 specimens containing rusts and *Lophodermiums* causing needle cast was given to Dr. Malcolm Wilson for identification.

IV. PATHOLOGICAL SURVEY OF FORESTS

The importance of the pathological survey of virgin forests where no mycologist has ever set his foot cannot be over estimated. This always brings new records of plant diseases

particularly where natural stands are felled for timber exploitation. From felled trees all stages of cull can be observed, and from the grounded and decayed logs, wind thrown branches and slash, the behaviour and intensity of fungus pathogenes can be estimated. A scientific study on the progress of rot in a stand should be based on the enumeration data. A study of this kind is of great importance in the economics of timber logging. It must be admitted that for various reasons proper enumeration of cull based on the statistical methods like the western countries cannot be done at this stage. Even though the survey of disease is conducted on the lines of exploration, this has its importance in the pathology of the forest crops in recording new diseases, in studying the intensity of diseases previously recorded, in understanding the predisposing factors and finally, in formulating methods of control. The status of a facultative pathogene is usually determined after intensive field work. Besides the natural stands and virgin forests, regenerations and plantations where important forest trees are raised with various silvicultural treatments on old forest sites are also inspected every year to record new diseases on younger stands artificially raised.

During this quinquennium an extensive survey (Figs. 11, 12 and 13) of mixed deciduous, semi-deciduous, semi-evergreen and evergreen forests was done in connection with the investigations of important tree diseases such as sal (*Shorea robusta* Gærtn.), teak (*Tectona grandis* Linn.), babul (*Acacia arabica* Willd.), khair (*Acacia catechu* Willd.), shisham (*Dalbergia sisoo* Roxb.), haldu (*Adina cordifolia* Hook.), gambhar (*Gmelina arborea* Linn.), salai (*Boswellia serrata* Roxb.), sain (*Terminalia tomentosa* W & A), bakain (*Melia azedarach* Linn.), *etc.*, in U.P., Bihar including Chhotanagpur, Bengal including Chittagong, Assam and Orissa including the Chhattisgarh area. Plantations of khair (*Acacia catechu*) babul (*Acacia arebica*) and mesquite (*Prosopis juliflora* DC.) were inspected in Sindh. Evergreen forests of Malabar including the *Sholas* of Nilgiris, and evergreen, dry deciduous (teak and rosewood) and sandal wood forests of Mysore and Coorg were also inspected. Plantations of teak were inspected in U.P. (Gorakhpur), C.P. (Raipur, Bilaspur, Balaghat and Mandla), Madras (Nilambur, Wynaad) and Coorg to look for any new infection attacking this valuable crop which is being given extensive trails in different regions under various conditions. A survey of Casuarina was made in 8 districts of Madras to study the cause of mortality in the plantations where the crop is raised under costal, inland and *padugai* (river-bed allevium) conditions. Several pathogenic fungi isolated from the diseased material are being examined in connection with the widespread mortality of this trees. Failure and mortality of *Evodia roxburghiana* in the plantations of Malabar and the gumuosis of wattles (*Acacia mollissima*, and *Acacia decurrens* Terone) in the Nilgiris are also being investigated after a careful survey.

Coniferous and hardwood forests of Simla, Lower Bashahr and Chakrata were surveyed for the purpose of collecting material of decay fungi and taking observations of various facultative pathogenes which produce heart-rot of conifers and oaks or otherwise kill them. Shillong forests were also inspected to study the pathogenicity of gall forming rust and to search for the alternative host.

V. SEED CERTIFICATION AND STUDY OF SEED BORNE PARASITES

Due to quarantine regulations prevailing in this country, seeds especially of forest trees are tested for the presence of injurious fungi before they are sent abroad. About 80 samples have been examined during the period certificates of health being given to 66, while 14 were advised to be rejected since they were believed to be contaminated. Of the 66 that were passed out as healthy, surface dressings by agrosan were given to a few since the injurious fungi were found to be only superficial.

Seed certification has opened a new problem of seed borne parasites some of which are believed to cause tree diseases. Isolations from the seeds are maintained in culture. The detailed study will be taken up later on.

AN UNPROVOKED ATTACK OF A TIGER

BY M. D. CHATURVEDI, I.F.S.
(*Inspector-General of Forests*)

What perhaps is hitherto unrecorded in the annals of big game hunting is an unprovoked attack of the feline family, notably that of a tiger, on human beings. During the last 20 years, I have followed tigers on foot, disturbed them at their meals and dragged their kills away to convenient spots for tying up *machans*, without as much as a protest from them. Only once did a tiger growl at me when he saw me approaching his carefully concealed kill. And, even then he was more curious than angry. Tigers are known to attack at the sight, or to be more precise at the voice, of man ; but only when they are wounded, mangy and out of condition. Unable to hunt game, they become man-eaters. Not unoften a mother when disturbed in her haunt where she is rearing her little cubs, will pounce upon the intruder but would seldom wait to eat up her victim. A tiger, otherwise, is much too egoistic an animal to take notice of a mere man. The very gait and height of man is puzzling to the animal world. Once I saw a wild boar, a peacock, a hen, a *Kakar* (barking deer) and a number of *chitals* (spotted deer), all having a drink around a muddy pool on a warm summer morning. The moment I loomed large on the horizon, they looked, wondered and disappeared. They would not accept me as a fellow denizen of the forest.

Viewed against this background, what happened the other day near Dhikala (Kalagarh forests, U.P.) sets a poser to the sportsman. On February 21, 1949, returning to my camp at Dhikala rather late at night from Ramnagar (District Naini Tal), where I had gone to see Ethel Mannin off after her brief stay with us in the wilds, I learnt that a woman had been attacked by a tiger in the afternoon. The unfortunate woman had gone to fetch grass with 3 others up a narrow hill stream (*nulla*). Her companions had heard her shout for help, but no more than just once. And, then her voice had been stilled. These terror striken women had run back to the cattle station in great scare and had told their incoherent tale of woe. They had not even seen the tiger.

The place of this mishap was about 12 miles from Dhikala. The news naturally took some time to travel. When I returned to Dhikala, it was 9 p.m. It was too late to do anything. I ordered, however, two of my elephants to proceed in the night so as to meet me early next morning at Boxar, the next camp which was only 2 miles from the spot, where the unsuspecting woman had fallen prey to the vile attack of a tiger.

The following morning, I reached the appointed place (Boxar) before sunrise. The husband of the deceased woman and her three companions were sent for and put in charge of the Forest Ranger on one of the two elephants to show us the way. I got up on the other elephant with my gun boy and a doctor friend who happened to be camping at the time at Boxar. We did not take long to get to the notorious *nulla* which in its upper reaches meandered through heavy cover. The bed of the *nulla* was practically dry and water existed only here and there alongside which shrill green grass grew. It was this grass which was much sought after for cattle and the unfortunate woman had gone to fetch. Fairly fresh prints in the *nulla* bed confirmed the presence of a tiger in the vicinity.

The stupefied women who guided us from the other elephant, at long last pointed out to us the approximate place of the tragic happening. We left behind these hysterical women on their elephant at a safe place. Our elephant, *Bijli*, stalked up the *nulla* bed cautiously, slowly and noiselessly. Hardly had we gone up a hundred yards that we heard the crack of a dry twig. Turning round, the keeper of *Bijli*, Latafat, drew my attention to the tiger who was standing above the *nulla* bank on my right, not more than ten yards away (see A in the diagram). Before I could wheel my rifle round to the right, the tiger had disappeared. *Bijli* did not take long to negotiate the bank. I saw the tiger again, but it soon merged into the landscape. The doctor friend sitting on my right got so excited that he developed a throat which was to prove a positive nuisance in the pursuit which followed. Never before, had I experienced the fear-complex affecting one's throat.

Latafat drove *Bijli* on, but the tiger had vanished. Finally we decided to go back to

the *nulla* and to look for the actual spot of attack. This was marked by the bill-hook of the deceased which lay alongside the sloping bank of the *nulla* (see B in the diagram). Following the drag marks, we soon came up to the remains of the dress worn by the victim (C) and finally reached the very spot where we had unexpectedly seen the tiger earlier (A). Examining the spot carefully, we found a bone of the leg of the unfortunate victim. There was nothing else. What happened to the rest of the body, we naturally asked ourselves. The tiger could not have devoured his victim, ornaments and all. As there were no drag marks on this bank, we decided to go to the other bank on mere speculation. A crow who was cawing away there, attracted us. Hardly had we gone a few yards that we found blood marks on grass at a height of about 2 to 3 feet. Obviously, the tiger had carried his quarry in his mouth, without leaving the least little trace on the ground. Immediately afterwards, we came up to a clump of tall grass followed by dense shrubs around a tree. The cover was impenetrable, dense and dark. As we stood there looking for drag marks, I was just in time to stop Latafat from getting down to the ground to examine further traces of the tiger. By the merest chance, I had spotted the eyes of the tiger in the covert. The tiger was looking at us. I could not afford to take a sporting chance at the tiger's head and asked Latafat to move to cover the side of the tiger. As *Bijli* took the next step, the tiger growled and bolted. We thought he had gone to the other bank of the *nulla*.

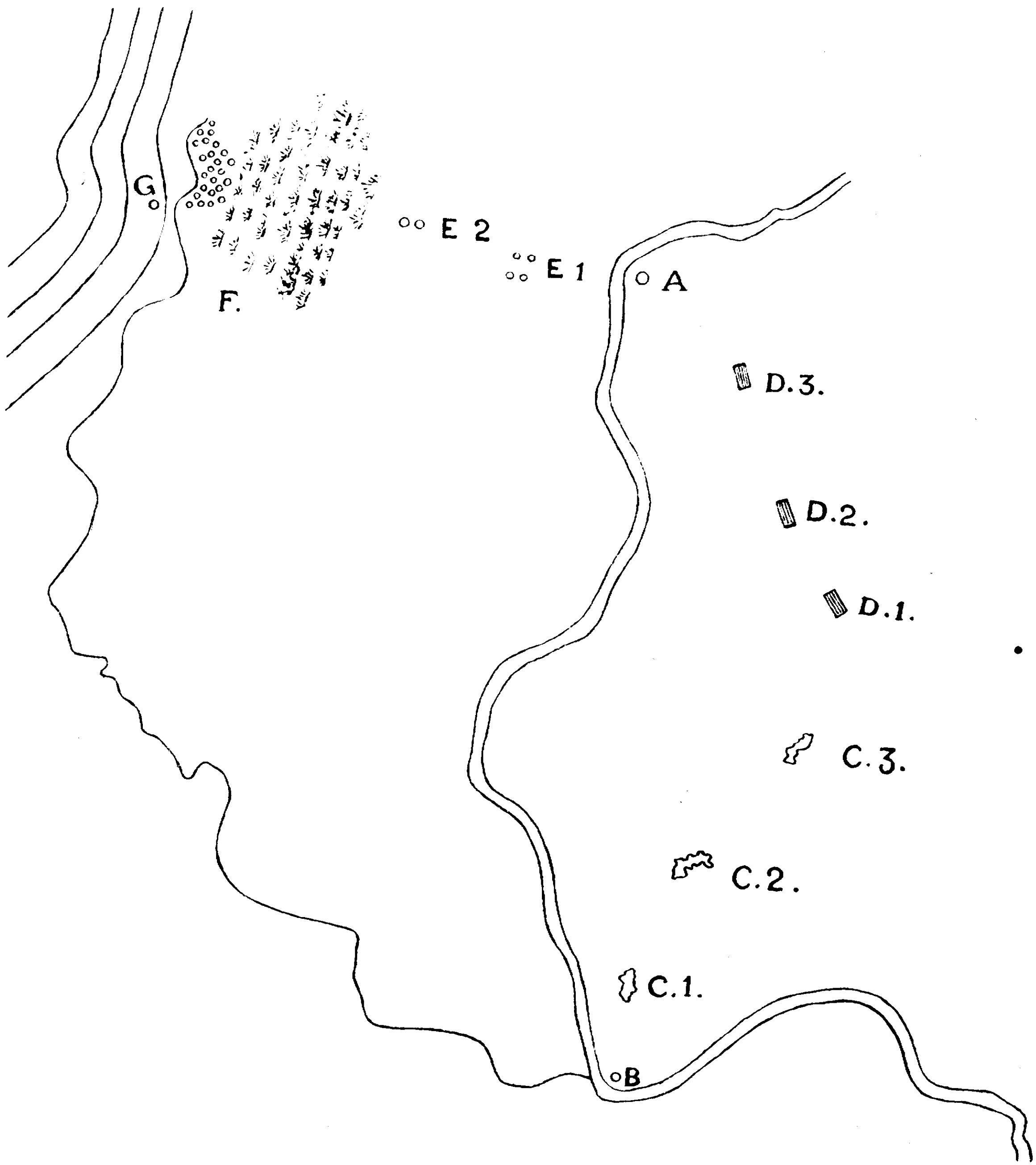
By now, the doctor's throat had deteriorated further.

We followed up the tiger to the other bank and searched him high and low, but to no purpose. Returning again to the bank where we had earlier spotted the tiger in the dense thicket we discovered that the tiger had ducked and had never gone to the other bank. For, Latafat saw him again in the tall grass. The tiger disappeared at the very sight of us. We moved on towards the thicket and circled round it. Despite *Bijli* making sings with her trunk and warning us of the presence of the tiger we could not see him. As we stood wondering, the tiger came out from the very spot where the elephant had given us a warning and began to climb the hill in front. I covered his backbone and as I was ready to fire, Latafat yelled at the tiger. The tiger stood still and turned round to look at us. In that split second, I had got him in the backbone. He had had both barrels.

We collected the tiger as also the upper part of the body of the woman. This, the tiger had hidden in the dense thicket to which he returned again and again, until he paid for his importunate behaviour with his life. The corpse was still bleeding, 20 hours after the death of the woman. Of the ornaments, she was wearing, I persuaded her husband to let me retain a silver ring as a memento.

The tiger measured 9′ 4″ between pegs. It was a young male in the pink of condition. How did he come to attack his unsuspecting victim is a mystery. The only possible explanation I can hazard for this amazing behaviour is that the tiger saw an object moving in the bed of the *nulla* and sprang on it, much in the same manner as the household cat does on any moving object. The tiger attacked the woman when she was cutting grass, without recognizing her. Her sitting posture was against her. Never would the tiger have attacked her, had she been standing. The attack was not pre-meditated. And, what appeared an unprovoked attack was no more than the proverbial curiousity of cats to which the unfortunate woman fell prey.

THE TIGER



DIAGRAMMATIC SKETCH

A. Where we first spotted the tiger and later found a bone.
B. Where the bill-hook lay, the point of attack.
C. Remains of the victim's dress.
D. Drag marks.
E. Blood trail.
F. Dense thicket, the retreat of the tiger, where the corpse lay hidden.
G. Where the tiger was shot climbing the hill.

MESSAGE FROM THE CHIEF CONSERVATOR OF FORESTS, MADHYA PRADESH, ON THE OCCASION OF THE DECLARATION OF INDIA AS AN INDEPENDENT SOVEREIGN REPUBLIC ON THE 26TH JANUARY 1950, TO THE FELLOW-WORKERS OF THE FOREST DEPARTMENT

On this very auspicious occasion of the declaration of our country as a sovereign independent republic, as the head of the Forest Department, I send to you all my cordial greetings.

Forests are a national asset on which our future welfare depends to a very large extent, and as professional foresters, it is the duty of us all jealously to protect them and so manage them as to ensure the maximum benefit not only for the present but also for future generations. In the words of our revered Prime Minister Pandit Jawaharlal Nehru this is a man's job and accordingly I earnestly appeal to every one of you for your whole-hearted co-operation without which no individual, however, high he may be, can achieve anything. We must all work together. I wish to emphasize that if all of us discharge our duties and responsibilities in the proper manner instead of clamouring for our rights and privileges, all will be well with us. It is also necessary to cultivate a sense of discipline which is the very essence of life and without which nothing substantial can be achieved. We must serve our State loyally and behave as true servants of the people.

Shri LAKHPAT RAI, I.F.S.
Chief Conservator of Forests, Madhya Pradesh

Many people in the country-side for whose benefit and welfare we work, often resent certain restrictions upon the use of forests which are essential for maintaining them in a perpetually productive state. One of your important duties is to avail of every opportunity to explain to them the necessity for such restrictions in their own interest and the interest of generations to come.

May we have abiding faith in the principles of truth and disinterested service placed before us by the Father of the Nation—Mahatma Gandhi—so that we may be able to contribute our share in creating the India of his dreams.

LAKHPAT RAI.

TORTRICID LARVAE DESTROYING FUNGUS GARDEN OF TERMITES IN LABORATORY

BY R. N. MATHUR

(*Systematic Entomologist, Forest Research Institute, Dehra Dun*)

An interesting case of destruction of the fungus gardens of termite by the larvae of an unidentified species of Tortricidæ (Lepidoptera) has been recorded during the summer of 1949, at New Forest, Dehra Dun. These caterpillars have got the habit of feeding on the sponge-like bodies known as fungus gardens and when these combs are completely destroyed, the white ants also perish. Thus several colonies of a mound-building termite (*Cyclotermes obesus* Ramb.), were wiped out and considerable difficulties were encountered in maintaining the termites for test experiments in the laboratory. The method adopted is as follows:—

Workers and soldiers in good numbers were collected by dismantling the field mounds and brought to the laboratory for experimental purposes. The individuals of each mound were caged separately in glass troughs or galvanized tin trays, having a sufficiently thick layer of damp soil at the bottom. In one set of artificial colonies, a few pieces of fungus-combs were placed in the centre and then covered over with mound earth, filling the cages about three-fourths in height. Water was sprayed from time to time to keep the soil sufficiently damp. Three or four small wood pieces of *Bombax malabaricum* (semul) and *Pinus longifolia* (chir) were also placed half buried and on the top surface of these artificial termitaria for feeding purposes. In another set, fungus-combs were not placed. Both sets of artificial colonies were kept outside in the verandah.

The workers repaired the mound, having built it vertically up in these cages within two or three days, and the inmates moved about actively in files inside the runways constructed along the sides and on the top surface. At times, slight feeding or grazing on the wooden pieces by the workers was also observed.

After a month or so of their confinement, the activity of termites was found considerably increased. The workers ran about in earthen passages, each holding a small globular food-body between its mandibles. The cause of this termite activity was due to the gradual destruction of the food supply from the fungus garden by the caterpillars. Their population was also undergoing partial reduction due to the cannibalistic habits in artificial colonies, for which termites are notorious. Thus, within two-and-a-half months, the laboratory colonies were completely wiped out and, on examination, numerous carcasses of termites were located scattered about inside these mounds. In laboratory colonies maintained without fungus-combs, the termites survived only for 6 to 10 days. It appears, therefore, that the fungus garden is indispensible to the existence of these fungus-growing termites.

The caterpillars are cylindrical, dull green, with scattered short hairs ; head and prothoracic shield dull yellowish brown. A mature larva is about 18 mm. long. Silken shelters entangling soil particles are spun by the caterpillars between the pieces of fungus-combs and close to the surface of the soil. The larvae, when disturbed, quickly retreat within these shelters. Pupation occurs inside silken webs. The pupa is about 7·5 mm. long, yellowish brown, sparsely hairy, with the anal segment bluntly rounded posteriorly, and having one pair of sub-apical dorsal and another pair of ventral books. Dorsal surface of abdominal segments bears six prominent transverse ridges developed on third and succeeding segments ; all ridges are close to anterior margins. The pupal period lasts about 5 to 7 days during June–September.

EXTRACTS

I

SPECIFIC FOR BLACK-WATER FEVER VITEX PEDUNCULARIS

Current Science Vol. 18, No. 12 for December 1949, p. 460, reports

"The discovery of a medicinal plant, which is a reputed specific for black-water fever, in the Rampa Agency tracts of the Madras Province was one of the important results of botanical investigations undertaken by the Botanical Survey of India, according to its annual report for the year 1947–48, just published. The plant, scientifically called, *Vitex peduncularis var. Roxburghiana*, was formerly known to exist only in Assam. Examination of other collections brought from the Rampa Agency has also revealed the existence of a number of plants, originally growing in distant regions like the Himalayas, Assam, Burma, and the Andaman islands.

Note by Dr. K. Kadambi, Assistant Silviculturist, Forest Research Institute, Dehra Dun

The seeds of this tree were imported from Assam into Mysore in 1937. Germination was satisfactory. The seedlings were put out in the compounds of various forest rest-houses. No artificial watering was done. These seedlings have attained girths of 8″ to 12″ in some of the forest rest-houses of Mysore Division, and have also commenced yielding fertile seed.

Note by M. S. Raghavan, Silviculturist, Forest Research Institute, Dehra Dun

About 1937–38, experiments on the artificial regeneration of Vitex peduncularis were started in the Madras Province, and about 1939–40 there were sufficient nursery plants to enable the Silviculturist to send to various forest stations in the Madras Province seedlings for entire transplanting. The species has been successfully grown in several of these places, and is doing very well in places with a west coast type of climate such as Kannoth near Tellicherry. Even in those early days, a research guard who was in hospital for black-water fever, was treated with a decoction made from the green leaves of some Vitex peduncularis plants grown in the Research gardens at Begur; the guard recovered rapidly, and is an active Research Forester in the same place now. Brandis's Indian trees mentions Vitex peduncularis on page 505, and lists the following localities for the species. Subhimalayan tract from Nepal eastwards, Assam, Khasi hills, Cachar, Chittagong, from the Rajmahal hills through Chutia Nagpur to Orissa and the Circars. Forest Botanists have observed the trees in the Vizagapatam District of the Madras State.

II

KING OF MAHOGANY TREES TO BE USED FOR U.S. FURNITURE

(Cosgroove's Woodworkers Report for September 1949, page 8)

New York, N.Y.—The most perfect mahogany tree ever discovered, felled in the Gold Coast Colony of West Africa, is now being made up into high-class furniture for American homes.

The tree was 55 feet long up to its first branches and 158 feet high. It measured 5·875 feet in diameter through its bole, and 18 feet in circumference. Because of its majestic size and the rare wealth of figured mahogany it contains, the tree is believed to have flourished in the equatorial Aderi Deni jungle since before the Pilgrim Fathers landed in America.

The giant tree will yield an estimated 80,000 feet of figured mahogany from its stump to its branches. The entire tree is usable for the very high quality of the finest veneers. Its rich profusion of unusual and beautiful formations of mahogany is most extra-ordinary. It has

every type of grain possible in one tree, swirl, burl, blister, knarl, mottle, fiddle back, figured flat cut, block mottle, broken stripe, plum pudding, slightly fiddle and broken stripe mottle, swirley figure and ripple.

Only one or two mahogany trees occur in an average acre of jungle growth, and from a 100 trees usually *one* only contains desirable figured mahogany. The distinction of the record-breaking tree can therefore be readily appreciated.

Though no accurate figures are yet available, it is believed that the tree is worth more than any other tree which has been shipped to America in recent years.

The U.S. is the largest buyer of Gold Coast mahogany. In the last year for which there are official statistics–1945—the U.S. bought 1,475,000 cubic feet of timber (mostly mahogany) from the Gold Coast.

III

By kind permission of British Information Services

PLYWOOD THAT RESISTS INSECTS AND FUNGI

New Products and Processes

In an effort to improve wood and to save it from damage caused by fungi, insects and weather, British manufacturers have produced a form of plywood called laminates. Sheets of wood (plies) bonded together by synthetic resins, these laminates are vastly superior to wood itself.

"Permaply"—as the laminates are called—though not a complete answer to the many problems of deterioration, marks a great step forward. A piece of the new material buried in open ground for 3½ years was completely unaffected; a piece of exterior grade plywood, used as a control, showed severe rotting and delamination—the plies had unstuck from each other.

Permaply's qualities result from a special treatment which, besides rot resistance, confers increased hardness, stiffness and durability. Permaply also withstands attack by insects, including the highly destructive white ant. The surface is proof against even tropical conditions without protection, but can, however, be finished with paint or decorative veneers.

The new material is extremely useful as shuttering for concrete and, in tropical or temperate climates, for portable or small buildings. In industry it stands up to moist atmospheres which would soon destroy wood. Other obvious outlets are in agriculture, in transport, and also in ship-building.

IV

By kind permission of FAO of the United Nations, New Delhi

FORESTS RICH AVENUE FOR ECONOMIC DEVELOPMENT, SAYS FAO

The increased use of forest products could become a major element in the industrialization of under-developed areas, says a report prepared by the Food and Agriculture Organization.

This report will be studied by the Sub-Commission on Economic Development which begins its Fourth Session on 17 April at Lake Success. Practical recommendations for financing economic development of under-developed countries, will be one of its main tasks.

The FAO report goes on to suggest that increased use of forest products would create employment in many countries, promote living standards in rural areas and stimulate international trade. Farmers would have addi-

tional incomes, more employment and better fuel and timber supplies.

By checking soil erosion, protecting watersheds and water supplies and facilitating flood control, forests can render significant services, adds the report.

Discussing present and potential supplies of forest products, the report asserts that from a global point of view, the productive forests of the world are inherently capable of yielding far greater supplies of wood than they have hitherto done, provided that they are managed in accordance with forestry principles and devastation is brought to a halt.

Softwood forests could eventually be made to yield much more wood per year than has ever been taken from them in the past. Whereas the 1948 yield of softwood forests was about 720 million cubic meters per hectare, it is estimated that the world's accessible softwood forests could yield 1,200 million cubic meters, "given reasonably adequate forest management".

Hardwood forests too, it is indicated, could provide substantially larger quantities of wood than are now being taken from them, although there have been examples of over-exploitation in some areas.

The report indicates that the undeveloped forest resources of the world are now generally limited to the timber stands in the under-developed countries of the world and to the USSR. On the other hand there is a deficiency for current needs in the industrialized countries of Europe and in vast heavily populated areas in Asia, as well as the Near East and North Africa.

For the present, reports the FAO, "these parts of the world where forest resources are in an undeveloped stage could, if these resources were developed, contribute to the raw material requirements of other areas, and particularly to those of the highly industrialized nations where demand is greatest.

In the long run, the growth of manufacturing facilities and consumption requirements in the presently under-developed areas themselves would tend to absorb the increasing forest production. There should still be a certain flow of rough timber from "surplus" areas to "deficit" areas within a region, but movement from one region to another would more and more be marginal only. Trade would increasingly be finished or semi-finished poducts, such as lumber, plywood and wood pulp.

In a regional review, the report indicates that in the South and East Asia, millions of Chinese rely entirely on bamboo for building and on grasses and shrubs for fuel. In India the apparent forest area per person is somewhat larger than in China, but here again millions of people have no wood at all. Other parts of Asia, such as Burma, Thailand, Malaya, much of Indonesia and the Philippines, are relatively well forested.

The region's needs for increased supplies are "enormous", the FAO adds, and new supplies of lumber that could be made available at reasonable prices "are bound to find a hungry market".

On the question of investments that would be required to launch a world-wide expansion of forest development, the report notes that no exact estimates are available. "Programmes for forest development can only be implemented after recognition of their importance by governments. Capital for such development will not be attracted unless the projects are sound in concept, precise in detail, and realistic in scope".

V

By kind permission of the Indian Standards Institution

INTERNATIONAL MEETINGS ON SHELLAC AND MICA

Wide Agreement on Standards Achieved

SESSIONS CONCLUDED

The meetings of the two International Committees on Shellac and Mica of the International Organization for Standardization called in New Delhi by the Indian Standards Institution (ISI), concluded their deliberations after four days of continuous sessions and arrived at substantial agreement concerning standards of these commodities on the international plane.

At these meetings, the countries represented included U.S.A., U.K., France, Belgium, Netherlands, Finland, Switzerland, Portugal and India. The International Organization for Standardization (ISO) was also represented by Mr. Henry St. Leger, the General Secretary.

The Shellac Committee, which met under the Chairmanship of Sardar Datar Singh, formulated international draft recommendations for standardization on three commercial varieties of Lac, namely, Seedlac, Shellac and Bleached Lac. Besides specifying the quality standards of the various grades of each product, the international specifications deal with standard methods of test for each physical and chemical characteristic which the various grades are expected to satisfy.

The Mica Committee, which met under the Chairmanship of Shri Chandmull Rajgharia, arrived at substantial agreement on standards concerning grading and classification of Mica. Grading in the Mica trade concerns the sorting of Mica pieces according to their size, while classification implies visual quality determination. All Mica is graded and classified according to methods accepted as standard in different parts of the world. This International Committee has now arrived at unification of these methods applicable both to grading and classification.

While agreement has been reached on most of the points, a few differences still exist which have been referred to a Working Commission appointed by the International Committee. The Working Commission is expected to report its findings not later than the end of February 1950.

The two International Committees were inaugurated at a combined session on 16th January by Dr. Syama Prasad Mookerjee at the Imperial Hotel, New Delhi. As a connected part of these meetings, an exhibition of Mica and Shellac products was held in the premises of the Cottage Industries Emporium, Queensway, New Delhi, between the 16th and 22nd January. The exhibition was well attended both by the general public and the concerned interests.

WHY STATISTICS*

(Abstract from the "Current Science" Vol. 19, No. 3, Page 86.)

Fluctuations are the fundamental feature of all measurements, whether they relate to the physical, biological or social sciences. But all contingent knowledge is based on measurements and observations which are subject to such variation. Each measurement or observation is only one of many possible similar sets, and hence there arise the statistical concept of a random sample from the totality of all such samples, i.e., the universe. These random samples enable one to draw valid conclusions about the universes from which they are drawn, with the aid of the calculus of probability. Such knowledge as is based on random samples is necessarily incomplete, and conclusions drawn therefrom, although valid,

* Abstract of the Presidential Address of Prof. P. C. Mahalanobis, F.R.S., General President, at the 37th Session of the Indian Science Congress, Poona, 1950.

are uncertain. But it is possible to estimate the valid measure of the degree of uncertainty with the help of the calculus of probability. Thus we have the following paradox :

If statistical theory is right, predictions must sometimes come out wrong ; on the other hand if predictions are always right, then statistical theory must be wrong.

This statistical or uncertain inference is in sharp contrast to deductive or absolutely certain conclusions. Pure mathematics is an example of such deductive logic. The certain inferences of deductive of deterministic views which one dominated the physical sciences have gradually given place to probabilistic-statistical inferences. All scientific knowledge being based upon evidences which are formally incomplete is only probable but never absolutely certain. Predictions based upon scientific knowledge must prove to be fallible or uncertain to an anticipated extent. But pure mathematics being fundamentally deductive in nature does not itself belong to the field of science.

The scope and range of the statistical method become larger and larger as they include within their domain the concepts of classical physics, the kinetic theory of gases, statistical mechanics and thermodynamics, biometry and so on, successively. At each successive stage, the importance of the fluctuations of variations in the phenomena become more and more marked and the statistical methods used for the study of these phenomena, more and more pronounced. Especially so is the case where more than one factor and their combinations have to be studied at one and the same time. Here the classical method of isolating and studying one factor at a time completely fails. It is only the statistical method of design of experiments and analysis of variance that can help us. In the industrial field also, where variations do exist, the statistical methods of quality control have enabled one to maintain the quality of manufactured products at a desired level. Statistical sampling is the most adaptable, rapid, economical and, in the true sense, scientific method of factual ascertainment in place of the traditional method of exhaustive census or attempted complete count. In certain cases where factors of variation are neither amenable to control nor to experimentation, the only approach possible is the statistical one. Thus statistics has supplied science with a general method for inductive inference and it has found growing practical applications in the affairs of everyday life. Statistics is essentially an applied sceince and in statistical research the greatest stimulus has always come from the need of solving practical problems.

Sample surveys with respect to crops are an instance in point. The advantages of such surveys over the older methods of complete-enumeration are greater speed, economy and precision. The governments not only in India but also elsewhere and the UNO have now been increasingly aware of the importance and usefulness of such sample surveys.

In India, the present great urge for solving the vital national problems is giving real strength to the progress of statistics, and statistics, no doubt will play an important part in solving these problems.

GROW MORE FUEL TO GROW MORE FOOD

BY M. D. CHATURVEDI, I.F.S.

(*Inspector-General of Forests*)

SUMMARY

The pressure of population in the rich Gangetic alluvium in the Uttar Pradesh has led to the upsetting of the agronomical balance between agriculture, forestry, pastures, human habitations and communications. The low, if not diminishing, crop returns find an easy escape in the continuous extension of agriculture. The progressive encroachment of the plough on tree-lands and consequent lack of firewood have given rise to the pernicious practice of diverting the farm-yard manure from village fields to village hearths, establishing thereby a vicious circle from which there is no escape. What is needed is the restoration of a balanced rural economy providing each group of villages with its complement of cultivation pastures and tree-lands. Further extension of cultivation in this region must be viewed with the greatest concern and attention should be diverted to the creation of fuel and fodder reserves for which purpose all State lands such as those along the railways, canals, roads and waste lands unfit for cultivation must be integrated. The prevention of private forests from wanton destruction is also indicated. Even the area under cultivation should be made to support at least 2 *babul* trees for acre.

Note:—This paper was read before the eighth meeting of the crops and soils wing of the Board of Agriculture and Animal Husbandry held on March 28–31, 1950. Much of this material is derived from book on Land Management in the United Provinces.

With a proportion as high as 70 per cent of its total land-area under cultivation, the Gangetic Basin in the Uttar Pradesh provides an illustration, par excellence, of how ill-planned land-use can reflect itself in low crop returns of a region. A critical study of the inter-relation between forests and agriculture in this densely populated region (density : 650 to a square mile) might well provide a cue for stepping up agricultural production elsewhere.

2. The maintenance of such a large area under cultivation in this region completely upsets the agronomical balance which must be maintained between agriculture, forestry, grazing grounds, human habitations and communications. This thoughtless extension of cultivation engulfing grazing grounds, village roads and tree-lands, has recoiled on itself by the operation of the law of diminishing returns. While there is no incontrovertible evidence of the progressive exhaustion of soils, the hypothesis that the Gangetic alluvium has reached its critical stage of the lowest production and is no longer subject to further deterioration is not free from an element of speculation. Forced rest brought about by the periodic failure of monsoons, high nitrogenous contents of rain-water and the action of the tropical sun in the restoration of fertility, are some of the factors which stabilize production to a large extent, but not sufficient to warrant the view that it is constant. The lag between the exhaustion of soils and forces and restitution, however, insignificant, is there. In a country, which exports one-fifth of its oil-seeds*, where fields are continuously cropped, where there is deep-rooted prejudice against the use of night-soil as manure, and where cowdung is burnt as fuel, the surprise is not that the production is low, but why it is not lower. The average wheat

* Oil cakes represent a valuable source of combined nitrogen for cash crops like sugar-cane, tabacco, cotton and tea. The annual export of 20 per cent of the total yield of oil-seeds, coupled with about 30,000 tons of oil cake means a regular drain on India's manurial resources (2).

and paddy yields of various countries are compared below

	Yield in pounds per acre	
	Paddy*	Wheat†
Siam	878	..
U.S.A.	1,481	846
Italy	3,000	..
Egypt	2,079	..
Japan	2,306	..
Canada	..	972
Australia	..	714
Argentina	..	780
Europe	..	1,146
Russia	..	636
INDIA •	805	636
UTTAR PRADESH ..	870‡	786§

3. The factors of locality, the resources of cultivators, age-long agricultural practices, and the natural forces of restitution of fertility bring about an equilibrium which govern crop production. *Ceteris paribus*, natural forces of restitution determine, for all practical purposes, crop returns which may be termed as the physical yield per acre. The ready response of the physical productivity of the soils of this region to artificial stimuli such as improved seeds, deeper ploughing and application of cowdung manures is indeed remarkable. To increase their output, one should put back into these soils at least a portion of what is annually taken out of them.

4. The low, if not diminishing, returns per acre find an easy escape in the extension of agriculture. The continuous encroachment of the plough has deprived cattle even of standing space which is now provided by public thoroughfares to the eternal despair of the motorist. Again, it is the unbridled extension of cultivation which has condemned human beings to live in the most congested of mud hovels. The progressive disappearance of tree-lands consisting largely of *dhak* patches has compelled the cultivator to burn his cowdung manure as fuel. What is needed in this region is the restoration of a balanced rural economy providing each group of villages with its complement of cultivation, pastures and tree-lands. The stage has reached in the Gangetic Basin, that any extension of cultivation should be viewed with the greatest concern and permitted only under a special licence which should be granted after careful scrutiny.

5. The progressive disappearance of tree-lands and consequent lack of firewood in cultivated areas has given rise to an evil practice which deserves special notice here. Unlike his confrère in China and Japan, who conserves every scrap of organic waste both garbage and sewage for the manufacture of vast quantities of compost, the peasant in the Gangetic Basin is compelled to burn his cowdung manure as fuel. The fact that the slow-burning properties of dung cakes commend themselves to the housewife in rural areas should not be construed to imply preference for this type of fuel. In areas, where fuel is locally plentiful, e.g., parts of Bundelkhand, the bulk of cowdung finds its way to manure heaps and only a small proportion of it is utilized as fuel for specialized cooking such as heating of milk, the smoking of tobacco by *hookah*, and more particularly during the rains when fire keeps best in dung cakes.

6. An idea, however, rough, of the amount of cowdung burnt away can be had by a reference to the 1944-livestock return in the Uttar Pradesh which shows the bovine|| population of rural areas in this tract in terms of adults as under :—

	Millions
Cattle (cows, bulls and bullocks) ..	15·66
Buffaloes	6·22

* Average of 3 years, viz., 1936–37, 1937–38 and 1938–39.

† Average of 1924–33.

‡ Crop cutting experiments of 1940 yielded for paddy, irrigated 1,100 and unirrigated 850 lb. per acre. Average weighted by area 870 lb. per acre.

§ General average.

|| Sheep, goats and pigs amounting to about 7 millions; and about half a million horses, ponies, etc., have been omitted. The dung of sheep and goats is seldom collected. The dung contribution of ponies provides a safety margin of 2¼ million tons approximately. The urban bovine population amounting to about half a million has not been considered, as their dung is generally not available for manurial purposes in rural areas.

The daily fresh dung production for adult cattle and buffaloes has been estimated by Burns (1) as 40 and 50 lb. per head respectively. The corresponding figures given by Acharya (3) are 30 and 40 lb. which may be accepted as a safe average. The annual yield of fresh dung of the bovine population will amount to 117 million tons. Allowing for loss in collection at 15 per cent, the net production may be placed at 100 million tons per annum, the chemical composition of which reveals on an average the following constituents (3)

		Million tons
Nitrogen	.. ..	1/4
Phosphoric acid	.. ..	1/10
Potash	.. ..	15/100

Preserved carefully with cattle-shed sweepings and urine which is four times as rich in nitrogen as dung, this should be ample to replenish the annual loss in fertility of about 32 million acres under cultivation in this region. The cumulative effect of the annual application of this manure which works out at $3\frac{1}{8}$ tons per acre is estimated to account for an increase of 35 per cent in crop production compared with unmanured fields.

7. The cycle of nature* ensuring interdependence between the vegetable and animal kingdoms, each sustaining the other, has been snapped by the cultivator who is compelled to divert at least about half of his farm-yard manure, if not more, from village fields to village hearths for lack of an alternative fuel. The loss occasioned by this evil practice of burning 50 million tons of dung means a sacrifice which would amount to about 15 per cent over current crop production. A ton of fresh dung along with sweepings and litter yields about two-fifths of a ton of dry cakes, the calorific value of which, as obtained by the writer, amounts to about half of common firewood species such as *babul*, *sissoo* and *nim*. The fuel value of a ton of fresh dung is, therefore, equal to that of one-fifth of a ton of firewood or, Rs. 4 at prices current in rural areas. The manurial value of a ton of fresh dung is Rs. 9 approximately†. Thus, the net loss involved in utilizing 50 million tons of manure as fuel amounts to 250 million rupees per annum, at Rs. 5 per ton. That these figures are highly conjectural, is not denied. All that need be conceded for them is that they give an idea, however, rough, of the loss involved in the use of farm-yard manure as fuel.

8. It will be seen that the creation of fuel plantations to ensure plentiful supplies of cheap firewood is the *sine qua non* of any improvement in crop yields of this region. Besides providing firewood to release cowdung for manurial purposes, such plantations would act as a *loo*-break, ensure cooler temperatures and arrest both wind-borne and fluvial erosion (4). Dr. Brandis visualized the role of village forests as far back as 1873, while the Government of India's Resolution of March, 1883 went so far as to recommend the acquisition of lands at rates in the environments of Rs. 2,000 per square mile for the creation of village forests as a stand-by during famines. In Dr. Voelcker (5), fuel and fodder plantations had their staunchest champion, who in 1893 stressed their importance in the rural economy of India with all the emphasis he could command. His recommendations found reflection in the Government of India's comprehensive resolution (Circular No. 22-F, dated October 19, 1894), which inaugurated the forest policy, still in force in India. In their report, the Royal Commission on Agriculture in India advocated the creation of village forests on climatic and physical grounds in addition to their fulfilling the villager's needs for fuel and fodder (2).

9. While Madras, Bombay, Ajmer-Merwara and other *ryotwari* tracts made some headway in respect of their agricultural forests, their creation in the Provinces burdened with *zamindari* rights remained an unrealized dream. The reason of this state of affairs is not far to seek. The land revenue policy assigning the ownership of wastelands to landlords and the tenancy legislation dispossessing the tenant of any tree-growing even on his holding have militated in the past against the establishment of village plantations. To save themselves the bother of looking after a self-grown tree on

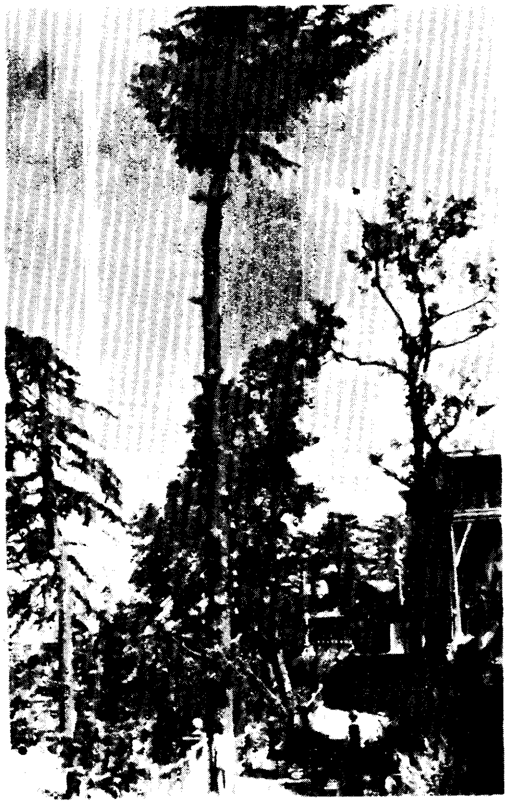
* Chemical manures applied continuously are apt to render crops toxic due to the deficiency in oxymones which are derived only from organic manures. Oxymones are to the vegetable kingdom what vitamins are to be animal world.

† 50 million tons of farm-yard manure burnt annually, if restored to fields, will account for a cumulative increase of 15 per cent over current crop production of 32 million acres. Each acre will thus get an additional $1\frac{9}{16}$ ton of manure and yield 15 per cent above the current average which in terms of wheat amounts to 118 lb (Table No. 1). At current prices, this will fetch about Rs. 15 or approximately Rs. 9 per ton of manure.

FIG. 1

FIG. 2

I



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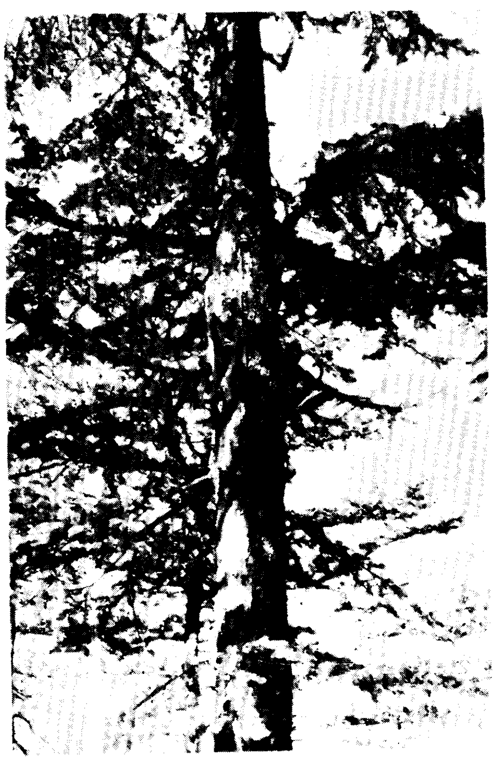

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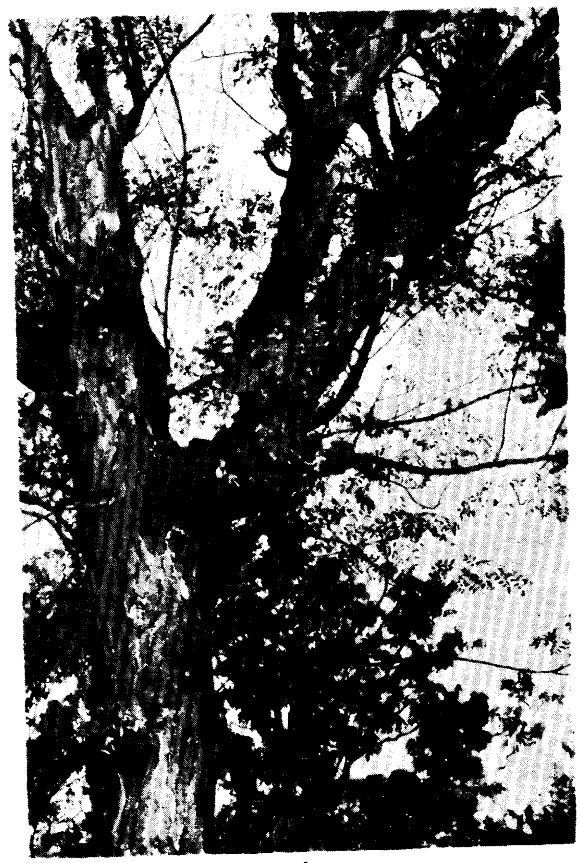

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PLATE 4

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their holding in the interest of their landlord, the tenants followed the line of least resistance, viz., to uproot it.

10. Unlike the *ryotwari* provinces where the ownership of wastelands vests in Government, practically every single acre of wasteland for the creation of village forests had to be acquired in the Uttar Pradesh from zamindars at exorbitant rates. Small surprise then, that for the last 70 years village forests have remained a laudable idea confined to forest literature and Secretariat files.

11. The Uttar Pradesh has given us a timely lead in the matter of the creation of fuel and fodder reserves by integrating the management of groves, roadside avenues, railway (Fig. 1) and canal lands. The control of private forests provides another source for firewood and small timber for the need of the agriculturists.

12. The tenant who had no proprietary interest in the past in trees grown on his holdings can do a lot to help himself, now that the Tenancy Act No. XVII of 1939 confers upon him the right to plant and own trees on his holdings. In this connection attention is invited to the vast possibilities which *babul* scattered in cultivated lands provides. Being a deep rooted species it does not compete for nutrition in the upper layers of soil which support agricultural crops. It provides excellent fodder, fuel, tanningbark and timber. Above all, its attenuated leaf surface and the nature of its crown do not shade crops sufficiently to affect production. All that the writer has observed is that the crop immediately underneath ripens about a week or so later. Occasional pruning to a height equivalent to the radius of the crown and the reduction of leaf surface to provide fodder for cattle, further decrease the possibility of the shading of crops. To force the cultivator to set apart a portion of his land for fuel and fodder production is to attempt the impossible. It is easier to persuade him to raise a few trees on his holding. At worst, the sacrifice involved is so negligible that he should learn to face it.

13. The implications of this far-reaching proposal can be best realized by focussing attention to the land amounting to 34 million acres ear-marked for agriculture in the Gangetic Basin. An average of two trees to an acre, (Fig. 2) which is not difficult to achieve, must be aimed at in the first instance. Convinced of the soundness of this proposal, the cultivator will himself work out the optimum number of trees which he could plant without affecting his crop production. These trees total up to a staggering figure of 68 millions equivalent to 2 million acres of *babul* plantations, with 34 trees to an acre about 35 ft. apart. The significance of this proposal can be appraised only when it is viewed against the area of existing state 'forests' which in the Gangetic Basin amounts to about a million acres only.

14. Before giving effect to this proposal on a large scale, it will be advisable to investigate the influence of high canopy of *babul* on crop production. The writer has had an area, which corresponds to the picture described above, under observation for some years in the Bareilly district. The fact that the idea has caught on and spread in the Doab districts (Bullundshahr, Aligarh, etc.) is a proof positive of its having carried conviction to the hardest of all practical realists, viz., the cultivator. 68 million *babul* trees dispersed over cultivated lands, apart from relieving fuel shortage, will check the force of March winds which adversely affect crop production and mitigate the desiccation brought about by the *loo* in the summer.

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SOME FUNGI AS WOUND PARASITES ON INDIAN TREES

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SUMMARY

The paper is intended to point out the dangers that arise due to maltreatments inflicted on our trees in avenues, parks and forests. Uncontrolled lopping of trees results in injuries through which fungi gain entrance into hosts. Seven such important fungi, namely, *Polyporus gilvus* (Schw.) Fr., *Ganoderma lucidum* (Leyss.) Karst., *Ganoderma applanatum* (Pers.) Pat., *Fomes badius* Berk., *Fomes rimosus* Berk., *Fomes senex* Nees and Mont. and *Fomes pini* (Thore.) Lloyd., have been described as they occur in nature as well as in culture and their pathology on important Indian trees has been discussed. The fungi are major heart rotting organisms and since the sapwood is not attacked, at any rate in the early stages, the infected trees continue to live until blown down by wind. It is needless to emphasize the difficulty of replacing these wind thrown shade trees along avenues where they are subject to adverse soil, moisture and weather conditions to which they are not exposed in their natural surroundings. Decay of the heartwood causes serious loss in timber and other economic products while attack in the sapwood tones down the general vitality of the trees and they are ultimately killed.

To safeguard trees from attack by wound parasites, therefore, all such malpractices should be stopped. Methods have been discussed as to how to protect trees from attack by wound parasitic fungi.

Introduction.—There are dangers that beset our tree species as a result of malpractices. Trees whether planted in gardens or parks for ornamental purposes, along avenues for shade, in orchards for fruits, in forests for timber, in plantations for fuel or fodder, are all designed by human agency to fulfil a specific purpose in the economic life of a country. In order to take full advantage of this, it is essential that the trees should be protected from untoward ravages and allowed to grow in conditions best suited for their growth. Careless cutting interferes with the growth, affects the yield of fruits or other minor forest products, and above all, exposes a tree to fungus infection. An affected tree not only loses its own value, but also becomes a source of danger to other healthy trees in the vicinity.

Along the Chakrata road from Dehra Dun to Kalsi at the foot of the Himalayas, various species of shade trees such as toon (*Cedrela toona*) shisham (*Dalbergia sissoo*), mango (*Mangifera indica*) and others are subjected to systematic lopping by villagers for fuel and fodder and the trees receive bruising injuries by passing vehicles (Pl. III, Fig. 11). Branches are frequently lopped to allow passage for communication wires (Pl. I, Fig. 4). Shade trees planted on the Grand Trunk road are lopped heavily for fodder. The villagers dig the roadside earth in the neighbourhood of trees for domestic purpose and thereby injure the roots. Fungi gain entrance into the trees through such wounds and on these avenues, many trees could be seen attacked by *Polyporus gilvus*, *Ganoderma lucidum*, *Ganoderma applanatum* and *Fomes senex*. Such fungi attack the heartwood of the trees with the result that the trees after a few years are easily thrown by wind. Thus the trees on the Kalka–Ambala road present a desolate look, while those on the Dehra Dun–Saharanpur road are hardly better off.

In Central India, myrabolan (*Terminalia chebula*), *Acacia* spp., siris (*Albizzia procera*), *Lagerstroemia* spp., tamarind (*Tarmarindus indica*) are planted as shade trees. These trees suffer from various maltreatments at the hands of villagers, as stated above. Debarking removes the natural resistance of the trees to fungus attack. The bark of sal (*Shorea robusta*) is often stripped and used as a container for shifting soil, etc., during repair work of Ghat roads in the Central Provinces.

In the Western Himalayas cultivators have a right to lop kail (*Pinus excelsa*) and chir (*Pinus longifolia*). They use the needle bearings twigs of these trees to cover the floors

of cattle sheds at night and remove them the next day with the refuse which later become compost. The charcoal from blue pine and chir forms excellent firewood in smithing. Deodar (*Cedrus deodara*), a valuable timber species, is also lopped to clear the surrounding land for sunlight. All these lopping injuries become footholds of attack by *Fomes pini* and in the hills of Kulu and Bashahr divisions of the Punjab the incidence of the disease on blue pine is high.

In the Simla municipal forests, deodar trees along roadsides are lopped of their lower branches and such trees are used as poles for carrying overhead communication wires (Pl. I, Figs. 1–3). Trees are subjected to pegging of iron nails and cross-bars. Fortunately there is no red heart fungus in the close vicinity of Simla, otherwise the effects of this policy would have been dangerous. It must, however, be pointed out that it is a false economy to risk the life of a natural tree of several decades of growth, which is difficult to grow on the hillsides or along the road, in order to save buying steel or wooden poles. It may be said that directly or indirectly such maltreatment affects the national economy and prosperity of the country. Whether on the roadside or in the forest, it takes years before a tree is capable of rendering useful service, and it is regrettable that human patronage is withdrawn just when it begins to be serviceable.

Methods.—Cultural characters of the fungi have been studied on 2 per cent malt agar in Petri dishes kept at 24°C in dark. Oxidase tests as described by Bavendamm (1928) were made by growing fungi on malt agar containing 0·5 per cent gallic acid or 0·3 per cent tannic acid. Fungi causing white rot usually form dark diffusion zones underneath the fungal mat on such media while those causing brown rot do not give any such reaction. Another method to distinguish white rot from brown rot fungi (Preston and Mclennan 1948) was successfully tried by growing fungi on malt agar containing 0·007 per cent gentian violet. White rotters bleach the violet colour of the medium while brown rotters do not.

BIOLOGY AND PATHOLOGY OF WOUND PARASITIC FUNGI

1. *Polyporus gilvus* (Schw.) Fr.

(Plate II, Figs. 5–8 and Text-Figs. 1–7)

Occurrence.—*Polyporus gilvus* is widely distributed in all the continents except Europe where it is said to be rare. In India, the fungus is common in the hardwood forests in the plains and is a parasite on shisham (*Dalbergia sissoo*), sal (*Shorea robusta*), rosewood (*Dalbergia latifolia*) (Pl. II, Fig. 5), babul (*Acacia arabica*), khair (*Acacia catechu*), bijasal (*Pterocarpus marsupium*) (Pl. II, Fig. 6), siris (*Albizzia procera*), Indian almond (*Terminalia catappa*) and *Cassia javanica* (Pl. II, Fig. 7). The fungus is also found in the temperate Himalayas as a parasite or a saprophyte on oak (*Quercus* spp.) (Pl. II, Fig. 8). It grows saprophytically on a wide range of hardwood species.

Pathology.—The fungus gains entrance in to living trees through wounds caused by fire, frost or mechanical means whereby dead sapwood is exposed. It is also a root-parasite on shisham and fruit-bodies of the fungus are common on exposed roots of uprooted windthrown trees. The widespread mortality of shisham of all ages observed in Dehra Dun was ascribed by Hafiz Khan (1923) as due to attack by this fungus. It is remarkable how frequently this fungus is associated with *Ganoderma lucidum* (Pl. II, Fig. 7) and sometimes with *G. applanatum*. Parker (1918) and Troup (1921) attributed the death of shisham in Dehra Dun and in Changa Manga in the Punjab as due to attack by *G. lucidum*. In one instance where shisham and siris were growing side by side, Hafiz Khan (1923) observed that *G. lucidum* was common on the latter but shisham was free from the attack. He concluded that *P. gilvus* was responsible for the mortality of shisham in Dehra Dun while in Changa Manga, the death of trees could be attributed to *G. lucidum*. At any rate, it is certain that both the fungi, individually or in conjunction are parasitic on shisham and other trees.

The symptom of attack on shisham is stagheadedness or the partial or entire yellowness of the crown. The fungus causes a white rot. The early stage of attack is the brown discolouration of the sapwood which later becomes light buff and spongy. Heartwood may also be attacked to a limited extent (Hirt 1928). Thin, light yellow mycelial sheets can be seen inside cracks in the wood. On sal sapwood the fungus causes 23 per cent loss in weight in 4 months.

Sporophore.—Fruit-body annual, hard, brittle, usually reflexed, single or imbricate, usually 5–6 ×

4–5 × 0.5–1.5 cm. Upper surface with shades of yellow, brown or red and either coarsely hairy, faintly zoned and not rugulose in *P. gilvus* forma *gilvoides* or smooth with concentric zonations, often with pustules in *P. gilvus* forma *licnoides*. Context 1–5 mm. thick, yellowish brown, soft, corky when fresh to woody when dry with transverse semi-lunar zonations (in section). Hyphæ thick-walled, yellow brown, unbranched (Text-Fig. 1) 2.9–4.2 μ broad. Thin-walled, hyaline, branched hyphæ with simple septa (Text-Fig. 2) 1.3–2 μ broad present only in hymenium. Hymenial surface yellowish brown, pores round, regular, 80–175 μ in diameter. Pore tubes 0.7–4–9 mm. long, uniform or stratified.* Basidia hyaline, clavate, 12–14 × 4 μ (Bose 1946). Basidiospores hyaline, oval with a globule (Text-Fig. 3), 3.3–5 × 2.5–3.4 μ, average 4.3 × 3.2 μ. Setae mostly projecting into the pore tube, abundant, thick-walled, dark brown (Text-Fig. 4), 10–20 × 6–10 μ.

Fungus in culture

(*a*) Growth characters.—Growth† 0.8–2 cm. in 7 days at 24°C in dark. Mat appressed with loose aerial hyphæ becoming appressed felty with age, granular. Colour 'cacao brown' (Rigdway 1912) in general with shades of 'mahogany brown', 'vinaceous tawny' 'tawny', 'russet', 'yellow ochre'. Reverse 'cameo brown', 'russet', 'tawny', 'mars brown'. Fruiting in 2–3 weeks. On malt containing gentian violet, growth vigorous and medium discoloured. On gallic and tannic acid agars, diffusion zones strong, growth trace to 1 cm. on gallic acid, none on tannic acid.

(*b*) Hyphal characters.—Aerial mycelium : (a) hyphæ hyaline, thin-walled, sparsely branched with simple septa (Text-Fig. 5), 2.5–3.8 μ broad ; (b) fibre hyphæ light brown, thick-walled with lumen large or nearly obliterated, septa simple (Text-Fig. 6), 1.7–3.3 μ broad ; (c) oidia‡ numerous, hyaline, thin-walled, cylindric (Text-Fig. 7), 4.5–12.5 × 2.5–4.1 μ. Fruit-body : normal, pores regular ; (a) basidiospores hyaline, oval, 3.3–4.1 × 2.0–2.9 μ, average 3.8 × 2.5 μ ; (b) setae abundant, thick-walled, brown, 18.3–28.8 × 4.2–6.6 μ. Submerged mycelium : thin-walled hyphæ as in aerial mycelium.

2. *Ganoderma lucidum* (Leyss.) Karst.

(Pl. II, Fig. 9, Pl. III, Figs. 10, 12, 13, and Text-Figs. 8–12)

Occurrence.—Ganoderma lucidum is mainly a tropical fungus but it also occurs in temperate regions. In Britain the fungus is listed as one of minor importance and is common on roots of oaks, on which it is probably parasitic (Cartwright and Findlay 1946). In America the fungus usually occurs on dead timber. In India, it is common and causes much damage on a variety of hardwoods such as shisham (Pl. III, Fig. 12), siris, babul (Pl. III, Fig. 13) khair, bamboo, gold mohur (*Poinciana regia*), nim (*Azadirachta indica*), tut (*Morus alba*), *Acrocarpus fraxinifolius* (Pl. II, Fig. 9, P. III, Fig. 10) and *Cassia javanica* besides being a saprophyte on cut stumps and fallen logs. The fungus causes a disease of areca palm (*Areca catechu*) and cocoanut palm (*Cocos nucifera*) in Sylhet (Assam) (Butler 1906), Mysore and elsewhere (Venkatarayan 1936). Venkatarayan also noticed the fungus on *Cassia siamea* and *Pongamia glabra*. Bose (1937) remarks that the fungus is common on roots of *Casuarina* trees.

Pathology.—The fungus behaves as a root parasite, entering the host plant through wounds. The affected trees are liable to wind throw. Fructifications develop at the base of trees at ground level or on exposed roots and also on soil. Sometimes they do not appear until the trees are uprooted or cut down. It causes a white rot and attacks both sapwood and heartwood and renders them spongy. On areca and cocoanut palms where the disease takes a heavy toll, the fungus usually attacks trees from about 10 years of age and upwards. The symptoms on palms as described by Venkatarayan (1936) are drooping, a yellowing of the lower leaves, followed sometimes by a reduction of the size of the crown which later dries up. Roots which are invaded by the fungus become discoloured, dry and brittle. A brownish gummy juice is secreted from the lower portions of the trunk. The wood becomes dark brown and yellow. The affected trees continue to bear a crop of nuts for some years but in less quantity than the normal. Venkatarayan also proved by controlled inoculation the slow but active pathogenicity of the fungus on palms. On sal sapwood the fungus causes 13 per cent loss in weight in 4 months.

Sporophore.—Fruit-body perennial, stipitate usually lateral rarely central, sometimes sessile, corky becoming woody later, usually 10–12 × 10–12 × 3–4 cm. but may grow up to 30 cm. or more. Upper surface shinning, laccate crust, ox-blood in colour, smooth, crust of vertical solid thick-walled, palisade

* Hirt (1928) has shown that stratified sporophores do not indicate perennial growth of the fruiting body which characterize the genus *Fomes*. In *P. gilvus*, the new growth is produced from mycelium within the wood at the base of the sporophore and not from any live mycelium of the previous year's fruit-body.

† Growth in all cases refers to radial growth.

‡ Cultural characters have been described from a spore culture of the fungus *P. gilvus* forma *licnoides*. It may be noted that oidia are formed in culture in the present isolate since the culture of the American form of the fungus as described by Hirt (1928), Lowe (1934), Davidson, Cambell and Vaughn (1942) and Nobles (1948) do not form oidia or any other secondary spores.

hyphæ about 40 μ long impregnated with dark orange varnishing substance which they secrete. Context brown, 2–5–10 mm. thick. Hyphæ in the context pale yellow, thick-walled, sparsely branched (Text-Fig. 8) 1.7–5.2 μ broad. Thin-walled, hyaline, branched hyphæ with clamp connections (Bosc 1934) 1.7–3 μ broad present only in hymenium. Hymenial surface whitish or creamish turning brown later, pores small, round, 90–250 μ in diameter. Pore tubes about 6–7 mm. long. Basidiospores brown, thick-walled, minutely verrucose, truncate at one end (Text-Fig. 9), 8.3–10 × 5.8–6.7 μ, average 8.8 × 6.4 μ.

Fungus in culture

(*a*) Growth characters.—Growth 1.5–2 cm. in 7 days at 24°C in dark. Growth optimum at 34°C, inhibiting at 46°C (Humphrey and Siggars 1933). Mat appressed felty with parallel longitudinal hyphæ in the advancing zone, white with shades of 'straw yellow', 'naples yellow', deepening to 'colonial buff'. Reverse 'ferruginous' darkening to 'kaiser brown'. On agar containing gentian violet, growth vigorous, medium discoloured. On tannic acid agar, diffusion zones strong, growth 2 mm. in 7 days. On gallic acid agar, diffusion zone weak, growth nil.

(*b*) Hyphal characters.—Aerial mycelium : (a) hyphæ hyaline, thin-walled, branched, with clamp connections (Text-Fig. 10), 2.5–4 μ broad ; (b) fibre hyphæ hyaline to light yellow, thick-walled, branched with or without clamp connections (Text-Fig. 11), 1.6–3.3 μ broad ; (c) chlamydospores abundant, terminal or intercalary, round to oval, hyaline, slightly thick-walled (Text-Fig. 12), 10–15.6 × 7.5–12.3 μ. Submerged mycelium : (a) thin-walled hyphæ and (b) chlamydospore as in aerial mycelium.

3. *Ganoderma applanatum* (Pers.) Pat.

(Pl. III, Fig. 11, Pl. IV, Figs. 14 and 17 and Text-Figs. 13–17)

Occurrence.—Ganoderma applanatum is cosmopolitan and is extremely common in most localities. The fungus exists in various forms which have been described by Humphrey and Leus (1931, '32) who also list their hitherto wide range of recorded hosts. The members of the group are common saprophytes on dead trees, logs and stumps but very often, they become wound parasites of living trees, gaining entrance through roots or lower portion of the trunk. In this country, the fungus attacks living trees of shisham, tut, (*Morus alba*), (Pl. IV, Figs. 14 and 17) babul, bamboo, toon (*Cedrela toona*) (Pl. III, Fig. 11), Jack (*Artocarpus integrifolia*), rohni (*Mallotus philippinensis*), *Cinnamomum cecidodaphne*. The fungus attacks dead sapwood of sandal (*Santalum album*) killed by 'spike-disease'.

Pathology.—G. lucidum enters host plants through wounds. The fungus attacks heartwood as well as sapwood. In early stages, the wood is bleached and light areas encircled by dark brown bands are formed and the bands mark the extreme limit of advance of the fungus. These bands move into the sound wood as the decay progresses. In late stages of the rot, the wood becomes white, soft and spongy. Since the heartwood is attacked severely, the trees are liable to wind throw (Pl. IV, Fig. 14). The fungus causes 'white' rot and on sal sapwood causes 44 per cent loss in weight in 4 months.

Sporophore.—Fruit-body perennial, usually sessile and reflexed, rarely with an eccentric stalk, single or imbricate, corky becoming hard and woody later, usually 14–16 × 10–12 × 3–5 cm. but sometimes as much as 40–50 cm. across. Upper surface dull laccate, zoned, uneven, with raised lumps, dull brown. Context dull brown to deep brown, silky appearance when torn, 2–3 cm. thick. Hyphæ in context yellow or brown thick-walled, branched (Text-Fig. 13), 1.7–6 μ broad. Hymenial surface light brown or light yellow, dull, pores minute, 75–250 μ in diameter. Pore tubes grayish brown, up to 1.8 cm. long. Basidiospores brown, thick-walled, minutely verrucose, truncate at one end (Text-Fig. 14), 6.4–8.0 × 4.8–6.4 μ average 7.1 × 5.1 μ.

Fungus in culture

(*a*) Growth characters.—Growth 1.7 cm. in 7 days at 24°C in dark. Growth optimum at 28°C, inhibiting at 34°C (Humphrey and Siggers 1933). Odour in culture faintly of tallow when mycelium is extracted from culture (Badcock 1939). Mat appressed, silky with small irregular felty areas, mostly white with shades of 'antimony yellow', and 'ochraceous tawny' developing in old cultures. Reverse with patches of 'tawny' to 'ochraceous tawny' under coloured areas. On agar containing gentian violet, growth vigorous, medium discoloured. On tannic acid agar, growth 6–7 mm. in 7 days and diffusion zones strong. On gallic acid agar, diffusion zone weak with a trace growth.

(*b*) Hyphal characters.—Aerial mycelium : (a) hyphæ hyaline, thin-walled, much branched with clamp connections (Text-Fig. 15), 1.6–6.2 μ broad ; (b) fibre hyphæ hyaline to light brown, thick-walled, sparsely branched (Text-Fig. 16), 1.6–2.5 μ broad ; (c) cuticular cells (Text-Fig. 17) which are swollen ends of hyphæ, thin-walled with hyaline contents. Submerged mycelium : thin-walled hyphæ as in aerial mycelium.

4. *Fomes badius* Berk.

(Pl. IV, Figs. 15, 16 and Text-Figs. 18–22)

Occurrence.—The type locality of *Fomes badius* is Arctic North America but there is little or no mention of the plant in American literatures and it appears to be rare in that country. The fungus has been described from Australia (Cleland 1935) and New Zealand

(Cunnigham 1948). In India, the fungus appears to be specific on babul and khair (Pl. IV, Fig. 16) and *Acacia sundra* and has been recorded in all parts where these trees are found.

Pathology.—The fungus gains entrance into the host plants through wounds caused by heavy lopping and bruising of barks by passing vehicles. Both sapwood and heartwood are affected. In babul, the whitish sapwood becomes buff coloured and in later stages assumes light brown to dark brown shade. Yellow or brown mycelium is present in the bark and may also be occasionally seen in small pockets in the sapwood. Heartwood is turned reddish brown and becomes soft and spongy. Chocolate coloured zone lines develop in the wood. In khair, light to dark red colour of the heartwood is bleached presenting a mottled appearance (Pl. IV, Fig. 15) and the hard and durable heartwood is rendered soft, spongy and fibrous. Small pockets filled with light brown felty mycelium appear in the wood. Black zone lines may develop. In *A. sundra* the reddish brown heartwood is bleached to a lighter colour and the wood turns yellow in which black areas develop. The latter also develops into apparently healthy wood. Roots rot and die from their extremities and the trees having no longer any hold in the soil are easily blown down by wind (Vahid 1928). On sal sapwood, the fungus causes 30 per cent loss in weight in 4 months.

Sporophore.—Fruit-body perennial hard, woody, sessile, reflexed, usually $7 \times 4 \times 3$ cm. or little larger. Upper surface dull brown, rough becoming rimose and black in old specimens, cracking. Context dull brown, brown or yellowish brown, corky when young becoming hard with age, about 1 cm. thick, with black lines in some sporophores ; hyphæ thick-walled, yellow or yellow brown, septate rarely branched (Text-Fig. 18), 2.8–5.5 μ broad. Hymenial surface plane or convex, bay-brown, dull, rough with fine branching ridges sometimes present, pores round or nearly so, 130–175 μ in diameter. Pore tubes stratified, 3–8 mm. long in each layer, ferruginous. Basidia hyaline, thin-walled, barrel shaped (Text-Fig. 19), $6.6–10 \times 4.1–6.6$ μ. Basidiospores round to oval, thick-walled (Text-Fig. 20), yellow brown, $5.8–7.5 \times 4.1–5.8$ μ, average 6.8×5.1 μ.

The fruit bodies of *Fomes badius* are closely allied to *Fomes rimosus* Berk. in general appearance. They are, however, distinguished by the character of the hymenial surface which is dull bay brown, rough with ridges in *F. badius* while in *F. rimosus*, it is usually deep brown, smooth with a sheen.

Fungus in culture

(*a*) Growth characters.—Growth 6–9 mm. in 7 days at 24°C in dark. Mat woolly becoming felty later with advancing zone indistinct. Colour 'colonial buff' in general deeping to 'antimony yellow' with shades of 'masicot yellow' and 'light buff'. Reverse 'cinnamon rufus', 'antimony yellow' and 'warm buff'. On malt agar containing gentian violet, growth vigorous, medium discoloured. On gallic and tannic acid agars, diffusion zones strong, no growth in gallic acid, 3–4 mm. in tannic acid in 7 days.

(*b*) Hyphal characters.—Aerial mycelium : (a) hyphæ hyaline, thin-walled, branched with simple septa (Text-Fig. 21), 1.3–2.5 μ broad ; (b) fibre hyphæ brown, thick-walled, 2.1–2.9 μ broad ; (c) setae hyphæ present in some isolates, apparently lacking in others, thick-walled brown (Text-Fig. 22). Submerged mycelium : thin-walled hyphæ as in aerial mycelium.

5. *Fomes rimosus* Berk.

(Text-Figs. 23–26)

Occurrence.—*Fomes rimosus* is widely distributed in South Australia, New South Wales, New Guinea, South Africa and America. The fungus is common all over India and is a facultative parasite on bahera (*Terminalia belerica*), *Terminalia tomentosa*, *Anogeissus latifolia*, *Lagerstroemia parviflora* and *Elæodendron glaucum* besides being a slash decaying organism.

Pathology.—Infection usually takes place through old branch stubs and punk knots and the fungus enters into the heartwood. The early stage of decay is indicated by a brownish yellow discolouration in the wood in which brownish black zone lines develop. The zone lines usually delimit the decayed wood from the sound. Later, short to long, narrow, elongated areas appear along the grain of the wood and the tissues inside these pockets become light yellow and fibrous. In advanced stages of decay, these pockets merge together to form soft, light yellow patches of decayed wood within the discoloured area where the wood remains apparently sound. Since the heartwood only is affected, at any rate in the early stages, the affected trees continue to live for some time until blown over. Sporophores develop abundantly through punk knots and broken branch-stubs. On sal sapwood, the fungus causes 6 per cent loss in weight in 4 months.

Sporophore.—Fruit-body perennial, hard, woody, sessile, reflexed, usually $5–9 \times 3–5 \times 2–3$ cm. sometimes more. Upper surface brown becoming black in old specimens, crustose, crust cracking into rectangular blocks. Context brown, tough 0.5–1 cm.

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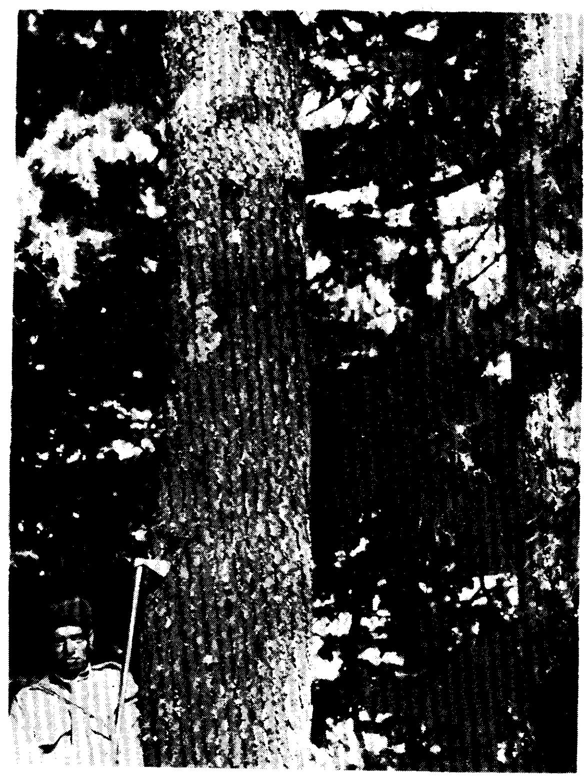

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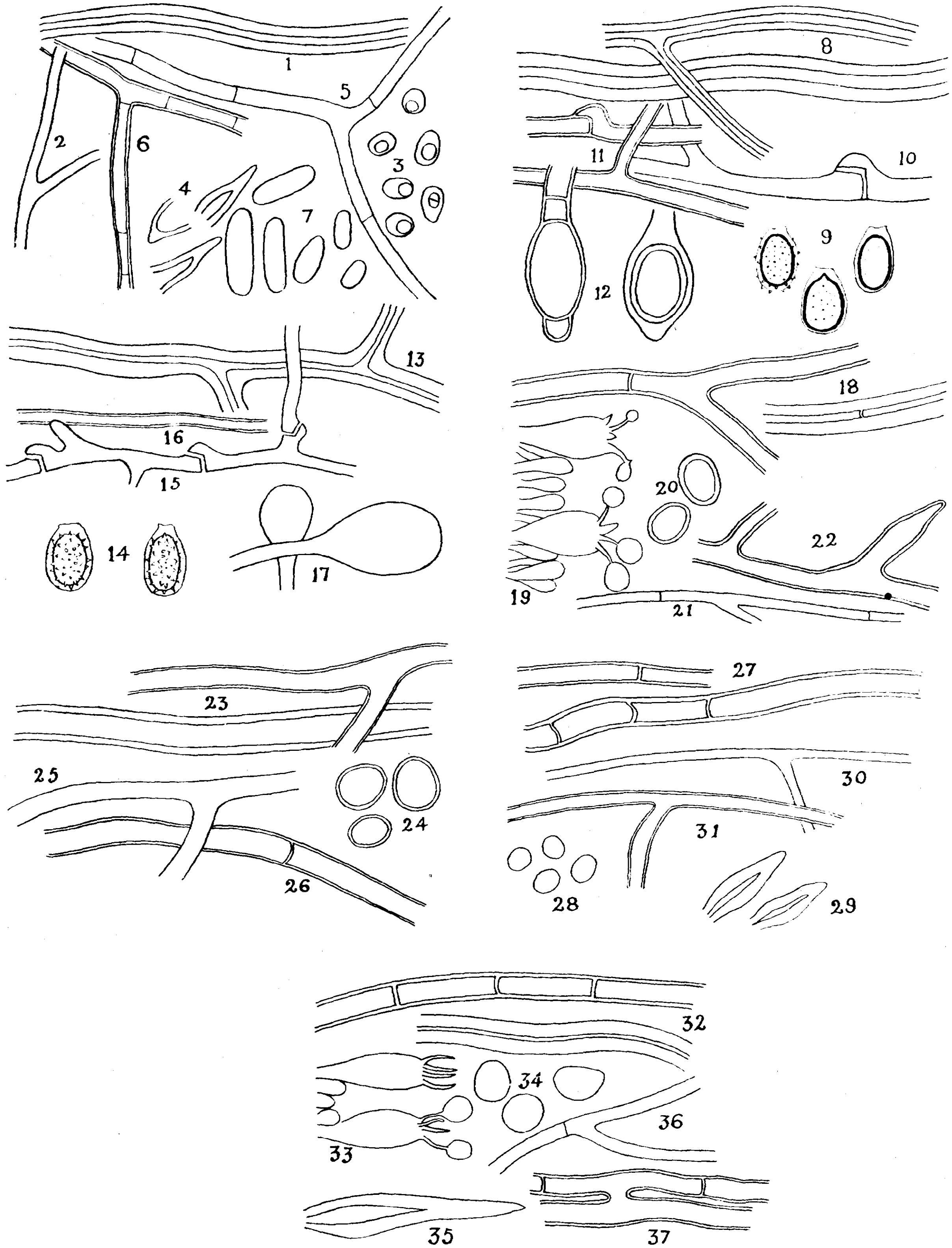
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broad. Context hyphæ light yellow or yellow-brown, thick-walled (Text-Fig. 23) 1.4–5 μ broad. Hymenial surface dull brown with pores round, minute, 4–5 per mm. Pore tubes in strata, concolourous with hymenium, slightly oblique, 1–2 mm. long in each layer. Basidiospores subspherical to oval, brown, thick-walled (Text-Fig. 24), 4.6–6.8 × 4.3–5.3 μ, average 5.5 × 4.6 μ.

Fungus in culture

(*a*) Growth characters.—Growth 8 mm. in 7 days at 24°C in dark. Growth optimum at 30°C, inhibiting at 40°C (Humphrey and Siggers 1933). Mat silky with zonations. Colour 'amber yellow' deepening to 'mustard yellow'. On agar containing gentian violet, growth moderate, medium discoloured. On gallic and tannic acid agars, diffusion zones strong, trace to 4 mm. growth in 7 days.

(*b*) Hyphal characters.—Aerial mycelium: (a) hyphæ hyaline or nearly so, thin-walled, branched (Text-Fig. 25), 1–5.6 μ broad; (b) fibre hyphæ light yellow, slightly thick-walled, branched (Text-Fig. 26), 2.1–5.2 μ broad. Submerged mycelium: thin-walled hyphæ as in aerial mycelium.

6. *Fomes senex* Nees and Mont.

(Pl. I, Fig. 4 and Text-Figs. 27–31)

Occurrence.—*Fomes senex* is widely distributed in the tropics. In India, the fungus is a wound parasite on avenue trees like Persian lilac (*Melia azedarach*) (Pl. I, Fig. 4), toon and mulberry (*Morus* spp.). Besides, it is also recorded on *Chickrassia tabularis*, Indian horse-chestnut (*Aesculus indica*), bakul (*Mimusops elengi*), plum (*Pyrus communis*), peach (*Prunus persica*), *Pyrus pashia* and other hardwood trees.

Pathology.—The fungus gains entrance into host plants through injuries. Both sapwood and heartwood are attacked. In early stages, the wood is changed to light yellow or brown discolouration. Thin, brown hyphal mat is noticeable in the affected tissue and the latter is ultimately converted into a brown, spongy mass. Since the heartwood is completely destroyed, the trees are liable to wind throw. On sal sapwood, the fungus cause 21 per cent loss in weight 4 months.

Sporophore.—Fruit-body perennial, sessile, usually reflexed, corky becoming woody later, usually 10–12 × 5–6 × 2 cm. but may be very large. Upper surface greyish brown, rough, concentrically zoned. Context brown, tough, 3–6 mm. thick; hyphæ yellow brown thick-walled, unbranched, septate (Text-Fig. 27) 2.1–5 μ broad. Hymenial surface brown, pores round, small, 75–160 μ in diameter. Pore tubes brown, stratified 0.6–1 cm. long in each layer. Basidiospores hyaline, thin-walled (Text-Fig. 28), 3.2–4.8 × 2.4–3 μ. Setae* brown, long, conical (Text-Fig. 29), 20–37 × 5–11 μ.

Fungus in culture

(*a*) Growth characters.—Growth 4–5 mm. in 7 days at 24°C in dark. Mat appressed to downy becoming felty later. Colour of mat 'maize yellow' and 'naples yellow' deepening to 'clay colour' and 'ochraceous tawny'. On gentian violet agar, growth vigorous, medium discoloured. On gallic and tannic acid agars, diffusion zones strong, growth 3–4 mm. in 7 days.

(*b*) Hyphal characters.—Aerial mycelium: (a) hyphæ hyaline, thin-walled distantly septate, sparsely branched (Text-Fig. 30), 1–2.8 μ broad; (b) fibre hyphæ yellow, thick-walled (Text-Fig. 31), 1–2.8 μ broad. Submerged mycelium. (a) thin-walled hyphæ as in aerial mycelium.

7. *Fomes pini* (Thore.) Lloyd.

(Pl. V, Figs. 18–21 and Text-Figs. 32–37)

The fungus had hitherto been described as *Trametes pini* (Thore.) Fr. in this country as well as in the continent of Europe but it is proposed to call the fungus as *Fomes pini*, a name commonly used by American mycologists, owing to resemblance of the plant more to *Fomes* than to *Trametes*.

Occurrence.—*Fomes pini* is widely distributed in the coniferous forests of North Temperate Zone (Percival 1933, Haddow 1938a). In India, it is a serious heart-rot fungus on blue pine (*Pinus excelsa*) in the Hazara division of the North-west Frontier Province and in Simla, Bashahr and Kulu divisions of the Punjab. It has also been recorded on deodar (*Cedrus deodara*), chir (*Pinus longifolia*) and fir (*Abies pindrow*) though the attack on these hosts is in no way alarming at present.

Pathology.—Infection takes place by means of wind-borne basidiospores during July to September and to a less extent in February (Hole 1914). Such infection is only possible when spores are able to alight directly on branch stubs or wound caused by various agencies. In 118 trees of Douglas fir which were decayed by *Fomes pini*, Boyce (1932) observed that 83 per cent infection had apparently taken place through branch stubs. In the Punjab hills where the villagers have a right to lop blue pine for fuel and fodder for cattle, the incidence of the disease is high. Freedom from virulent attack of deodar has been due to special protection against lopping

* Corner (1932) distinguished 2 varieties depending on the form of the setae.

and other maltreatment afforded to it under law. A possibility of spread of infection through root grafts has been suggested by many workers (Hafiz Khan 1910, Sher Singh 1924, Hole 1933). Recently Dr. T. W. Childs and Mr. J. W. Clark* have proved quite conclusively that this fungus occasionally spreads through root grafts though they believe that in their forests such spread seems to be only for short distances and is of no practical importance.

Though the fungus causes a heart rot in the trunks of living coniferous trees, there is difference of opinion as to whether it can attack living tissues besides destroying the heartwood of its host. Percival (1933) did not find hyphæ of *Fomes pini* in the sapwood of red spruce (*Picea rubra*) though hyphæ were observed in the heartwood of six trees he examined, and concluded that *Fomes pini* enters red spruce as a saprophyte. Haddow (1938b), on the other hand, views that the fungus is definitely parasitic and besides destroying the heartwood of its host, it attacks living tissues. Although the disease is predominant in mature and overmature stands, Haddow states that early infection commonly results in a typical rot in the bases of young white pines and the fungus is often the primary cause of butt rot of old trees. Boyce (1948) remarks that in general the decay is confined to heartwood but occasionally in Douglas fir, western larch and lowland white fir, it attacks living sapwood after decay of the heartwood is well advanced. Hafiz Khan (1910) and Hole (1933) observed hyphæ in the heartwood as well as in the sapwood of blue pine attacked by *F. pini*.

In initial stages of attack, the trees show swollen nodes, knotted or bottle shaped stems or may be covered with bushy epicormic shoots (Pl. V, Figs. 18–21). The incipient stage of decay is indicated by a pinkish or brownish of purplish red discolouration of the heartwood for which the terms 'red heart', 'firm red rot', or 'firm red stain' is applied. The wood is usually firm at this stage. The advanced stage of the rot resembles those formed by *Fomes annosus*. Elongated pockets parallel to the grain of the wood develop and these are separated by apparently sound wood. Inside the pockets, the wood is reduced to a mass of white fibres. Zone lines have not been observed in blue pine infected by the fungus but they are said to occur in some cases (Boyce 1948). The presence of sporophores, swollen nodes, punk knots is a reliable indication of decay. Information at present available (Boyce 1948) on the effect of red stain and pocket rot on the strength and serviceability of various timbers shows that there is little weakening of timber with incipient decay caused by *F. pini*. Red stained jack pine has been shown (Atwell 1948) to have ample strength to permit its use for purposes for which sound jack pine of similar grade has been specified. Jack pine with less than 10 per cent firm pocket rot can be used where somewhat less rigid strength requirements are called for, while jack pine poles having pocket rot in not more than 30 per cent of the cross-section could be used for a number of purposes such as rural telephone lines. Hence trees should be marked out showing initial symptoms of attack and converted. Such removal will prevent sporophores forming on infected trees and check the spread of the disease. On chir sapwood, the fungus causes 4 per cent loss in weight in 4 months.

It is suggested that in areas where the incidence of *F. pini* on blue pine is high, deodar may be planted to replace blue pine. In the Punjab hills since the villagers have a right to lop blue pine, and not deodar, they have to be provided with some alternative arrangement for the supply of fodder, etc. Secondly the infection is likely to spread from blue pine to deodar since the latter is not immune to attack by *F. pini*.

Sporophore.—Fruit-body of varied form, perennial or potentially so, sessile, usually reflexed, conchate, broadest at base, margin thin, hard, woody, usually 6–8 × 6–8 × 5–7 cm. thick (base), but sometimes as large as 26 cms. across. Upper surface at first brown becoming gray to black with age, glabrous, cracking, zoned. Context brown, woody, 1–4 mm. thick, hyphæ thick-walled yellow brown, septate (Text-Fig. 32), 2.5–4.5 μ broad. Hymenial surface brown, pores round to angular to dædaloid, size varied. Pore tubes usually stratified (indistinctly), brown, 1.5–7 mm. long in each layer. Basidia hyaline, thin-walled, cylindric (Text-Fig. 33) 8.3–10 × 4.2 μ, with 4 sterigmata on each, up to 5 μ long, 1 μ broad. Basidiospores hyaline or light brown, thin-walled, round to oval (Text-Fig. 34), 4–5 × 3.3–4 μ. Setae abundant, yellow to dark brown to brownish red, conical, thick-walled (Text-Fig. 35), 20–55 × 6–11 μ, projecting up to 42 μ beyond hymenial layer.

* These workers in the Division of Forest Pathology, United States Department of Agriculture, Portland, Oregon, have stated their observations in personal communications to the senior author.

Fungus in culture

(*a*) Growth characters.—Growth slow, 1 cm. in 7 days at 24°C in dark. Growth optimum at 20°C, inhibiting at 32°C (Humphrey and Siggers 1933). Mat cobwebby to cottony becoming felty later. Colour 'cream buff', 'light buff', 'honey yellow', and 'buckthorn brown' deepening to 'antimony yellow', 'warm buff', 'honey yellow' and 'chamois' with age. Reverse 'kaiser brown'. On malt agar containing gentian violet, growth moderate, medium discoloured. On gallic and tannic acid media, diffusion zones moderate, trace to 5 mm. growth in 7 days.

(*b*) Hyphal characters.—Aerial mycelium : (a) hyphæ hyaline, thin-walled, simple septa (Text-Fig. 36) 2.5–4.3 μ broad ; (b) hyphæ light yellow to brown, thick-walled, branched, with yellow or brown contents (Text-Fig. 37), 2.5–5.9 μ broad. H-connections and coiling of hyphæ common. Submerged mycelium : thin-walled, hyaline hyphæ as in aerial mycelium.

Discussion and Conclusion.—From the foregoing account, it is evident that lopping should be restricted in order to safeguard the trees from attack by wound parasites. Every diseased tree continues to be a source of danger to its neighbouring trees. Hence the diseased trees should be removed. The fungi are major heartwood rotting organisms and if the trees in their early stages of attack can be spotted out, maximum utilization of wood can be derived from them. As the disease progresses, the rate of decay increases while increment of the heartwood does not occur proportionately with the result that the volume of sound wood becomes less and less with age. In initial stages of attack, wood does not show any appreciable decrease in strength properties. In the light of work done in other countries (Boyce 1948, Atwell 1948) on the strength and serviceability of wood attacked by *Fomes pini*, it is quite likely that blue pine, in its early stage of attack by *F. pini*, may be utilized for purposes for which sound blue pine of similar grade is specified. Development of sporophores indicates an advanced stage of decay, since they are usually formed a few years after the fungus establishes itself within the hosts. Spores that develop within the sporophores serve as a means of dissemination of the fungus. This danger of spread of the disease can be eliminated if the infected trees are converted before the sporophores develop on them.

Wound protection by wound dressing has been advocated especially in shade and avenue trees. These wound dressings are sufficiently toxic to fungus spores to prevent or hinder their establishment. Once, however, a fungus has established itself within the host, no chemical will eradicate the pathogen without injuring the host, hence the need for prompt wound dressing. Asphalt as water emulsions or diluted with various solvents is a popular wound dressing. A mix of dry Bordeaux and raw linseed oil has been considerably used. Marshall and Waterman (1948) have discussed at length in a practical bulletin the methods of wound treatment.

Wound dressing of the cut stumps in forests during thinning and felling of mature trees to prevent their colonization by wound parasties does not appear practicable but in some cases, such treatment lessens stump infection by harmful parasites and thus reduces the inoculum of the fungus and checks the spread of the disease in the forest. Rishbeth (1948) was able to reduce the incidence of stump infection by *Fomes annosus* by creosoting the cut surfaces immediately after felling.

Resume.—We have, in the above, tried to elucidate one of the dangers of lopping from the scientific point of view, but many other view-points are also involved here. Bread, fuel wood and fodder are the most vital needs of the children of the soil. In an overpopulated country, when the production is not sufficient to meet these needs, all kinds of malpractices are bound to spring up and society has to connive at them. It is true that the state can put an end to these by means of legislation, but in an intensively agricultural country where there is a real shortage of fodder for livestock, this will be extremely unfair, as long as no other satisfactory arrangement is made. To grow fodder trees in special areas in the neighbourhood of villages, initially managed by the state, later on handed over to the village community to be looked after as community forests, seems to be the only solution of the problem. Rural education will help a great deal in the formation of public opinion and sense of responsibility necessary to make this a complete success.

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EXPLANATION OF PLATES

PLATE I

Figs. 1, 2.—Living *Cedrus deodara* have been lopped of their lower branches to make passage for communication wires. Note that cross bars have been pegged to hold insulators.

Fig. 3. A living *Cedrus deodara* being used as a light post.

Fig. 4. A living *Melia azedarach* attacked by *Fomes senex*. The sporophores are shown by arrows. The branches of this tree were frequently lopped to make passage for communication wires.

PLATE II

Fig. 5. Sporophores of *Polyporus gilvus* on fire scar of a living *Dalbergia latifolia*.

Fig. 6. A frost canker at the base of a living *Pterocarpus marsupium* with sporophores of *P. gilvus* on the canker.

Fig. 7. Sporophores of *P. gilvus* and *Ganoderma lucidum* at the base of living *Cassia javanica*. The wound is due to damage done by lawn mower and garden roller.

Fig. 8. Sporophores of *P. gilvus* forma *gilvoides* on an oak stump (x½).

Fig. 9. Sporophores of *G. lucidum* on roots of living *Acrocarpus fraxinifolius* and also on soil. The tree was growing on a lawn and the roots were injured by garden roller.

PLATE III

Fig. 10. A young *A. fraxinifolius* planted to replace a mature one killed by *G. lucidum*. The young tree will eventually be attacked and killed by the fungus which is producing numerous sporophores on the ground.

Fig. 11. Sporophores of *Ganoderma applanatum* on an avenue tree of *Cedrella toona*. The wound was produced by bruising of passing vehicles.

Fig. 12. Sporophores of *G. lucidum* on a living *Dalbergia sissoo* in one of the irrigated plantations of Changa Manga, Punjab.

Fig. 13. Sporophores of *G. lucidum* at the base of a living *Acacia arabica* on a lawn. Damage on surface roots is probably caused by garden implements.

PLATE IV

Fig. 14. A wind blown tree of *Morus alba* attacked by *G. applanatum* with sporophores of the fungus on the tree. This tree species is frequently lopped for fodder.

Fig. 15. Sporophores of *Fomes badius* showing hymenial and upper surfaces and the rot produced by the fungus on the heartwood of *Acacia catechu* (x¼).

Fig. 16. Sporophores of *F. badius* on a scar of a living *A. catechu*.

Fig. 17. The tree of *Morus alba* shown in Fig. 14 before being wind blown. The sporophores of *G. applanatum* can be seen on the trunk.

PLATE V

Fig. 18. Swollen knots and sporophores of *Fomes pini* on *Pinus excelsa* in the Simla Hill States. Note the hill beyond has become bare and erosion has set in.

Fig. 19. A typical forest of *Pinus excelsa* in Lower Bashahr division, Punjab. Note that trees on the right hand side of the road have been frequently lopped while those on the left are undisturbed.

Fig. 20. *Pinus excelsa* in Lower Bashahr division showing initial symptoms of swollen knots due to attack by *Fomes pini* prior to the development of sporophores.

Fig. 21. A living *Cedrus deodara* in Lower Kulu division, Punjab with sporophores of *Fomes pini*.

TEXT FIGURES

Figs. 1–7. *Polyporus gilvus*. Fig. 1. Thick-walled hypha from context. Fig. 2. Thin-walled hypha from hymenium. Fig. 3. Basidiospores. Fig. 4. Setae. Fig. 5. Thin-walled hypha in culture. Fig. 6. Fibre hypha in culture. Fig. 7. Oidia.

Figs. 8–12. *Ganoderma lucidum*. Fig. 8. Thick-walled hypha from context. Fig. 9. Basidiospores. Fig. 10. Thin-walled hypha in culture. Fig. 11. Fibre hypha in culture. Fig. 12. Chlamydospores.

Figs. 13–17. *Ganoderma applanatum*. Fig. 13. Thick-walled hypha from context. Fig. 14. Basidiospores. Fig. 15. Thin-walled hypha in culture. Fig. 16. Fibre hypha in culture. Fig. 17. Cuticular cells.

Figs. 18–22. *Fomes badius*. Fig. 18. Thick-walled hypha from context. Fig. 19. Hymenial layer showing basidia. Fig. 20. Basidiospores. Fig. 21. Thin-walled hypha in culture. Fig. 22. Thick-walled setae hypha in culture.

Figs. 23–26. *Fomes rimosus*. Fig. 23. Thick-walled hypha from context. Fig. 24. Basidiospores. Fig. 25. Thin-walled hypha in culture. Fig. 26. Fibre hypha in culture.

Figs. 27–31. *Fomes senex*. Fig. 27. Thick-walled hypha from context. Fig. 28. Basidiospores. Fig. 29. Setae. Fig. 30. Thin-walled hypha in culture. Fig. 31. Fibre hypha in culture.

Figs. 32–37. *Fomes pini*. Fig. 32. Thick-walled hyphæ from context. Fig. 33. Basidia. Fig. 34. Basidiospores. Fig. 35. Setae. Fig. 36. Thin-walled hypha in culture. Fig. 37. Fibre hypha in culture.

All × 1300 except Figs. 4, 29 and 34 × 550.

SURFACE GEOLOGY, VEGETATION AND PLANT SUCCESSION

PART II

BY DR. G. S. PURI, M.SC., PH.D. (LUCK. & LOND.), F.L.S., F.G.S.*

(iii) BOX HILL, SURREY

Introduction.—The surface geology and general activities of man in the Tring area were found to have largely determined the nature and development of plant communities in these woodlands. Investigations were, therefore, extended to another Chalk area—Box Hill, North Downs—to see whether the same factors were operating there as well.

Box Hill is the name given to one of the Chalk Hills of the North Downs after box—*Buxus sempervirens*—one of the most common plants in this area. The Chalk uplands here rise from the general level (200 ft. above sea-level) of the country to an elevation of 500–600 ft. (Fig. 10). The strata of the Chalk at the Box Hill dip towards north-west and form a steep escarpment facing towards south-east and a dip slope of the Chalk which runs in a north-west direction. Along the foot of the west facing side of the hill River Mole cuts back its course into the strata of the Chalk. This side of the hill and west sides of the nearest valleys are therefore more damp than the other sides of the valleys. The northern slopes of valleys, that run parallel to the escarpment, are similarly moister than the southern sides.

The slope of the Chalk escarpment and the side of the hill along the river are very steep and Chalk outcrops appear on the surface at most places. These slopes for the most part are clothed with woods of box—ash at lower levels and beech—yew at higher levels.

The dip slope of the Chalk is formed of clay-with-flints deposits mixed with Pebble Gravel and Sands, which being mainly non-calcareous produce a slightly base deficient soil. The major plant community here is an oak wood.

The general continuity of the dip slope is broken by a number of narrow, dry valleys, incised deeply into the strata of overlying Chalk. Some of these are merely shallow basins, while others are deep (over 100 ft.), with steep sides. In most of these valleys, especially at lower levels Chalk out-crops appear on the surface. These valleys must have at one time borne springs or water channels, which cut back into the strata of the dip slope. The lowering of the water table, brought about probably by excessive cutting down of forests or/and changes in climate resulted in an extinction of these streams. The configuration of the valleys (Fig. 10) suggests that this area had a more humid climate in the past, which greatly influenced the eroding action of streams in cutting deeply into the dip slope. This constant erosion has great influence on the development of vegetation and tended to keep the plant communities on this slope in seral stages. The interest of these dry valleys lies in that while the main type of vegetation on the dip slope is an oak wood, the valleys invariably bear ash—box—hazel and beech—yew communities, which are characteristic of the slope of the Chalk escarpment. The purpose of this study, therefore, is to discover causes for this interesting feature of plant distribution.

The vegetation over the slope of the Chalk escarpment generally resembles that of the escarpment woods at Tring and the Chilterns, with the difference that ash community is better developed here. In this respect it resembles more closely that of the woods of the South Downs escarpment.

The vegetation of the dip slope closely resembles the general distribution of plant communities in the Whippendell Woods, which are themselves related to seres A_0 and A from the plateau woods of the Chilterns. The oak woods from the dip slope at Tring resemble the oak wood at this place, excepting that the vegetation of the valleys at Box Hill has no parallel at Tring. The vegetation of these valleys resembles on the one hand that developed

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on the slope of the Chalk escarpment and, on the other hand, that of the valley in the Whippendell Woods.

VEGETATION

(Tables 7 to 9 at end, Figs. 11 and 11a)

(i) *Slope of the Chalk escarpment and west slope (Scarp face) of the hill.*—The main tree communities at lower levels are ash—box and on higher levels beech—yew. The frequency of ash follows a gradual decrease from lower to upper levels and of beech an increase. Yew follows beech and box follows ash though box may extend higher up than ash and is present on the dip slope as well.

Tree seedlings at lower levels are mainly ash and box ; at higher levels a few seedlings of yew and beech were seen. The ground flora types at the lower levels are *Mercurialis* and *Mercurialis—Urtica.* At upper levels bare areas are common.

(ii) *Main dip slope.*—The chief tree community here is oak. In felled places or where there are locally small patches of sandy soil birch accompanies oak. But the presence of oak saplings among birches seems to show that oak—birch is only a successional stage. Ash may be rarely present on the dip slope and box occurs as a shrub. Beech and yew may be present but they do not seem to regenerate here. Their position near the scarp slope and the valley-side on the dip slope seems to show that these trees have migrated to the dip slope and do not form a part of the natural succession.

Tree seedling on the dip slope are of oak and ash. Under beeches and yew, holly seedlings are present. *Mercurialis prennis* and *Rubus fruticosus* agg. are the main ground flora communities.

(iii) *Valleys on the dip slope.*—Tree community in shallow valleys and at lower levels in deeper valleys is mainly ash—box or ash—box—hazel. At the higher levels on valley-sides beech—yew or beech community occurs commonly. The frequency of these trees on valley-sides increases or decreases in the same way as on the slope of the Chalk escarpment.

Tree seedlings are chiefly ash and box. On higher levels, however, seedlings of beech and yew are present. The ground flora types at lower levels are *Mercurialis* and *Mercurialis—Urtica* ; at upper levels *Rubus fruticosus* agg. and bare areas are present.

Soil conditions on the two slopes, it will be noted, are different and as seen in the Tring area are related to the nature of the dip of the strata of Chalk. The vegetation is intimately related to the base status of the soil. On the scarp slope and sides of deeper valleys ash—box—hazel or ash—box community is governed by the calcareous or base rich soil. On slightly base deficient soils on higher slopes beech or beech—yew communities are present. These communities, as in the Tring area, are seral stages.

On leached soil of the dip slope oak is the edaphic climax. Oak—birch community is a successional stage.

The study of vegetation at this place, therefore, confirms and extends the results described in previous examples that the main type of woodland is determined by the nature of surface geology and the biotic element.

A point to which attention may be drawn here is that the vegetation of the north-eastern sides of the dry valleys lying at right angles to the Chalk strata dip is generally composed of beech—yew communities, ash being rather rare, found only at lower levels (cf. Table 8). The south-western slopes bear ash community and beech—yew is rare even at the upper levels. Running parallel to this feature of plant distribution is the nature of the surface soils on the two slopes. On the north-eastern slopes it is calcareous or at least of a high base status. On the south-western slopes the surface soils, especially at higher levels, are somewhat poor in bases. These soils seem to be drier as compared with those of the opposite slope and contain raw humus on the surface.

This feature of plant distribution is apparently related to the surface geology and nature of the two slopes. The north-eastern slope is scarp slope and the slope of the south-western side runs along the dip of the strata and corresponds to a flushed area. The opposite slope, like scarp slope, is leached-area.

(iv) EPPING FOREST

(Tables 10, 11 at end, Figs. 13 and 13a)

Introduction.—In order to illustrate the relationship between vegetation types and surface geology from another area on the dip slope

of the Chalk, the vegetation of the Epping Forest was considered. The strata of Chalk in this region are very deep, approximately 300–400 ft., below the surface. A greater part of the region studied is formed of London clay, which over-lies the Chalk and forms the main stretch of the country towards the south. Towards the north, sandy clays of the Claygate Beds overlie the London clay and pass up through the Bagshot Sands into the Pebble Gravel. The Bagshot Sands and Claygate Beds are seen on the sides of the hills, the tops of which are capped by brown clayey soil with numerous stones of the Pebble Gravel. On the London clay there are local patches of Glacial Gravel at Long Hills and Cuckoo Pits and of alluvium in the area now occupied by pasture land.

Topographically the area studied is a shallow saucer-like basin in the centre of which there is a small pool, called Connaught Water. The level of the country gradually rises from the pond towards the north, where occur numerous hills rent by narrow dry gullies.

The vegetation was studied along a transect, south to north, from the Connaught Water to the Church of the Holy Innocents (Fig. 12). A greater part of the vegetation floristically resembles seres B and C (also sere A to some extent) from the plateau woods of the Chilterns. The succession in seres B and C was shown by Watt to be from Grassland→oak wood→beech associes→beech wood.

Vegetation in Relation to Surface Geology

In the vicinity of the Connaught Water at Cuckoo pits and Buttonseed Corner ash—oak is the main tree community. Mature ash are rather more numerous than standards and saplings. Oak of all age classes were present. Hawthorn and holly were common. A few standards of hornbeam and beech were present.

Tree seedlings were mainly holly ; however, a few oak and ash were also seen.

Of the ground flora species *Rubus fruticosus* agg. was constant and abundant. Bracken was co-abundant at some places. *Oxalis* was often present.

This community is developed on Glacial Gravel which provides a slightly base deficient soil with pH between 4·49–5·11. Humus is of the mull type. The ash-oak community at some places seems to reproduce itself while at others it has already changed into an ash—oak—beech, and appears to be an edaphic association.

This community merges towards north into an oak—hornbeam—beech community. Oak and hornbeam are constantly present, but standards of beech are rarely found. Both hornbeam and beech have forked stems and were probably coppiced in the past. Holly has a high frequency and an odd shrub of hawthorn may also be present.

Tree seedlings were mainly holly and a few oak and beech were also present. Ground flora species were bracken, *Holcus mollis* and *Rubus fruticosus* agg. *Lonicera* and *Teucrium* were also present occasionally.

The geological structure here is made up of London clay deposits mixed with Sands. This community also seems to be an edaphic association related to the underlying rock.

The greater part of the pasture seems to be on a sort of sandy alluvium which is kept in such condition by human influence. Abutting directly on the pasture on the north side are high ridges, the main community on which is beech. Beeches here are mature trees and except for a few shrubs of holly there is no other vegetation on these ridges. There is no regeneration, even of holly, indicating that the beechwood here tends to deteriorate into a heath. This community occurs on Pebble Gravel, which produces a soil poor in bases and acidic on the surface. A thick carpet of undecomposed humus indicates the tendency of the soil towards mor formation.

Near the Church of the Holy Innocents there is a birch community with mature *Betula* and some saplings of beech and oak. Tree seedlings here are of oak and beech.

Of the ground flora species bracken is most abundant, accompanied frequently by *Holcus mollis* and *Rubus fruticosus* agg.

The present abundance of birches in this area was brought about by human interaction. The natural vegetation was felled and the soil organic matter burnt in recent years. This was conducive to the invasion of this area by

birch. The birch community is clearly developing into an oak-beech community as evidenced by seedlings.

The factors outlined therefore indicate that :—

(1) Ash—Oak—beech, Oak—hornbeam—beech and oak-beech communities in this region are edaphic associations bound up with the underlying geological strata.

(2) The occurrence of ash is associated with a local patch of Glacial Gravel on the London clay.

(3) The beech woods on Pebble Gravel deteriorate into holly and then into a heath. The succession at such a place proceeds from Birch→Oak-beech→beech→holly→heath.

(4) The birch community in this area is artificially created by the biotic factor and develops into Oak-Beech community.

This further confirms the conclusion that the natural plant communities in the south of England woods are largely the outcome of surface geology.

CONCLUSIONS AND SUMMARY

The examples studied lie in the London Basin. The dominant rock in this region is Chalk, masked by Clay-with-flints and deposits of later geological ages of which Clays, Sands, Loams, Gravels and Alluvia are common. These deposits are variously exposed and in the centre of the syncline of the London Basin make up all or the major part of the surface soils. Thus the strata of the Chalk seldom affect the vegetation in this area.

On the slope of the Chalk escarpment the soil is usually immature and rich in lime. On account of the characteristic topography and composition of the rock it is obvious that a high base status of the soil would be maintained along this slope. On the dip slope, however, as already noted, the surface soils being made up of leached residue of the Chalk or deposits of reassorted material, derived mainly from rocks not particularly rich in calcium carbonate, are lime deficient. These soils must have been rich in bases when immature but have now attained stability and are leached of minerals, especially lime. Thus the soils on the two slopes of the Chalk are fundamentally different and would be expected to bear distinctive vegetation types.

The distribution of various tree communities has been shown to be associated with soil conditions in each of the areas studied. On the basis of these results from selected areas it may be interesting to consider a broader correlation of the vegetation with surface soils in the London Basin. By a general view of the vegetation of this Basin as a whole, represented diagrammatically in Fig. 14, the following general conclusions are reached :—

(1) Ash and beech communities as a rule are confined to scarp slopes, while oak is the main type on the dip slope.

(2) On the scarp slope on immature soils ash forms a seral community usually on lower levels. Its presence in valleys, or elsewhere on the dip slope is associated with similar types of soil provided locally by patches of Glacial Gravel, Silty loam, or an out-crop of the Chalk. On account of the low lime content of the soil and intensity of leaching the ash community here seldom remains in a seral stage and either develops into an edaphic association of ash—oak—beech or is succeeded by an oak wood.

(3) Similarly, beech normally forms a seral community on the scarp slope at higher levels, and on account of its low lime requirements, it becomes dominant on immature soils on the scarp. It migrates to similar immature soils on valley-sides on the dip slope, and occurs plentifully as a seral stage on scarp slopes in deeper valleys (cf. Box Hill). In local patches of Sands or Pebble Gravel or in disturbed oak woods on the dip slope beech forms an oak-beech community. Again, depending upon the lime content of the soil and leaching the oak-beech either reproduces itself as an edaphic association or is succeeded by beech probably finally degenerating into a heath.

(4) On the dip slope of the Chalk oak is a leached edaphic climax reproducing itself naturally. On Sands or in areas from where oak has been felled and/or vegetation burnt, birch becomes a common plant. It is, however, succeeded by Oak→Oak-beech and finally to heath.

Forest vegetation in the London Basin area can be viewed as a series of successions in the general sequence :——Mixed deciduous colonizing woodland→Oak wood→Heath, in which the early seral stages are preserved by : (i) geological features (nature of rock and the amount of calcium) (ii) by immature topography—scarp slopes versus dip slopes (iii) by location of accumulation areas and (iv) by biotic influences.

This sequence of succession agrees closely with the one suggested by Pearsall for the whole of Britain.

It is interesting to note that oak woods in this area are richer in species compared with those occurring in the north of England. There is ample evidence that these woods had long been subjected to interference by man, and as has been shown there is a great variety and preponderance of immature soils in this area. Immature soils bear mixed woodlands, which are richer in species and as the immaturity of the soil in this area is apparently preserved by the geological structure of the principal rocks the woods with numerous species (seral stages) tend to be preserved. As in the north of England woods, the introduction of new species is facilitated both by human activity and immature soils.

I am deeply indebted to Professor W. H. Pearsall, F.R.S., for guidance and helpful criticism of this paper. My thanks are also due to Dr. F. W. Jane, who has kindly shown a keen interest in this work and helped in many ways for its successful termination. I am thankful to the Government of India, Ministry of Education for award of a Research Fellowship for studies at the University College, London.

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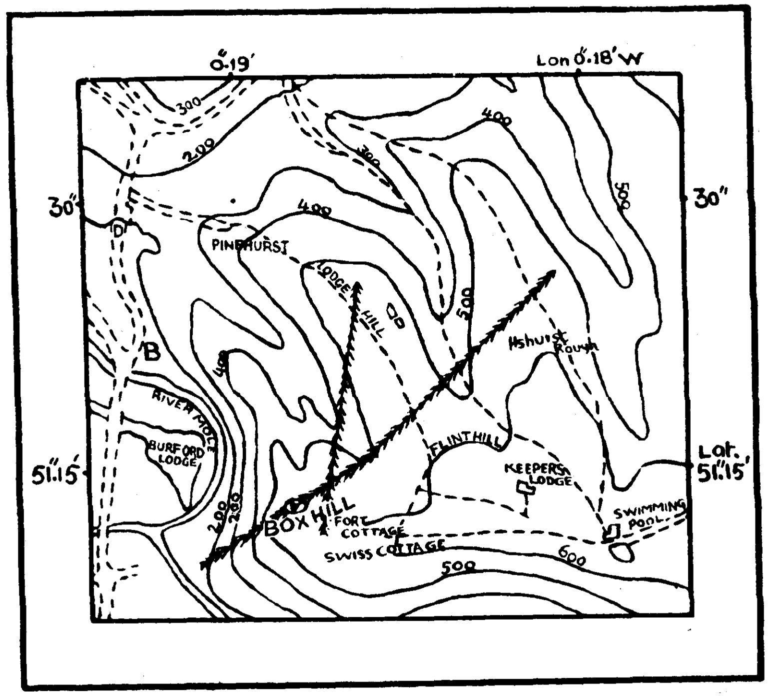

FIG 10.—A map marking positions of the transects studied at the Box Hill.

Scale 6″ = 1 mile.

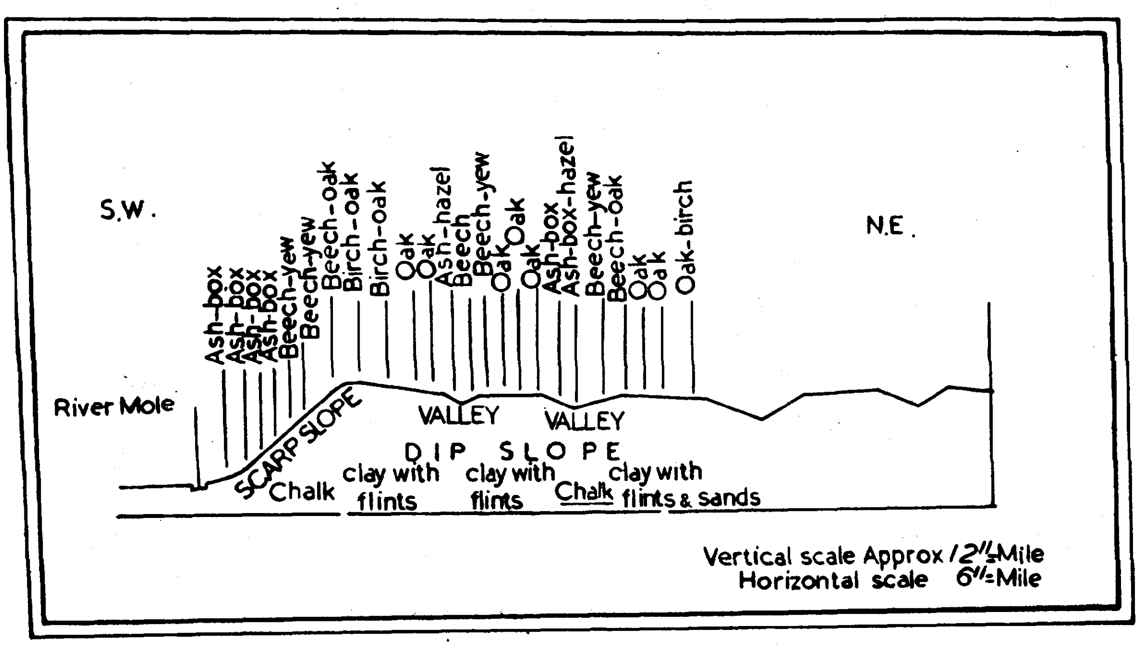

FIG. 11.—Distribution of tree communities on the two slopes of the Chalk at Box Hill.

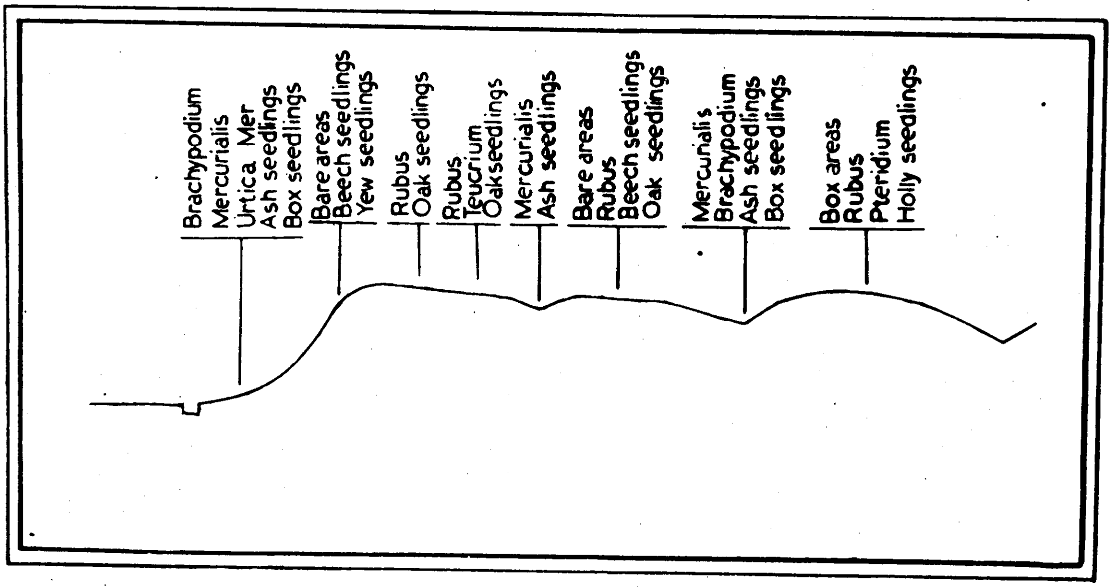

FIG. 11a.—The distribution of given types of ground flora and named species of tree seedlings at Box Hill.

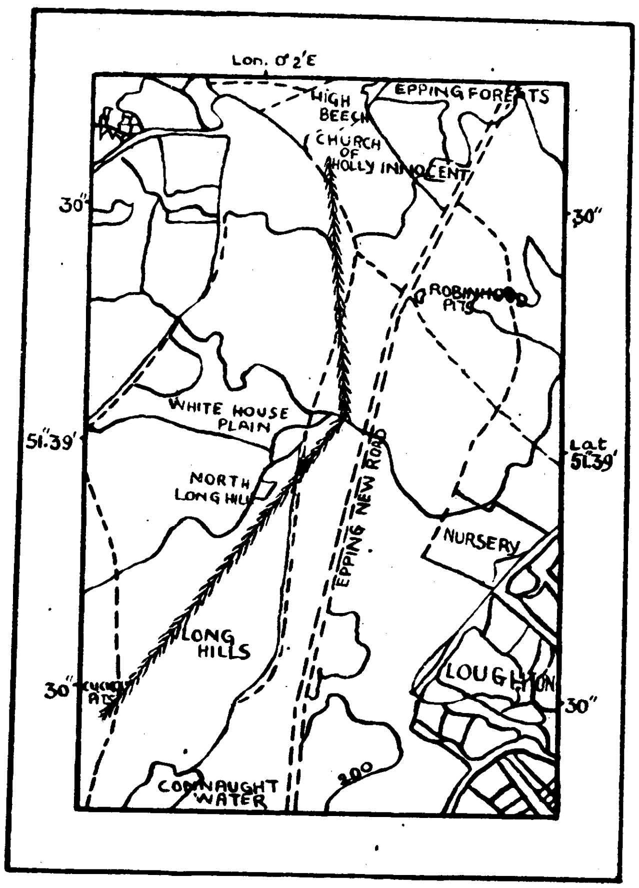

FIG. 12.—A map showing position of the transect studied in the Epping Forest.

Scale 6" = 1 mile.

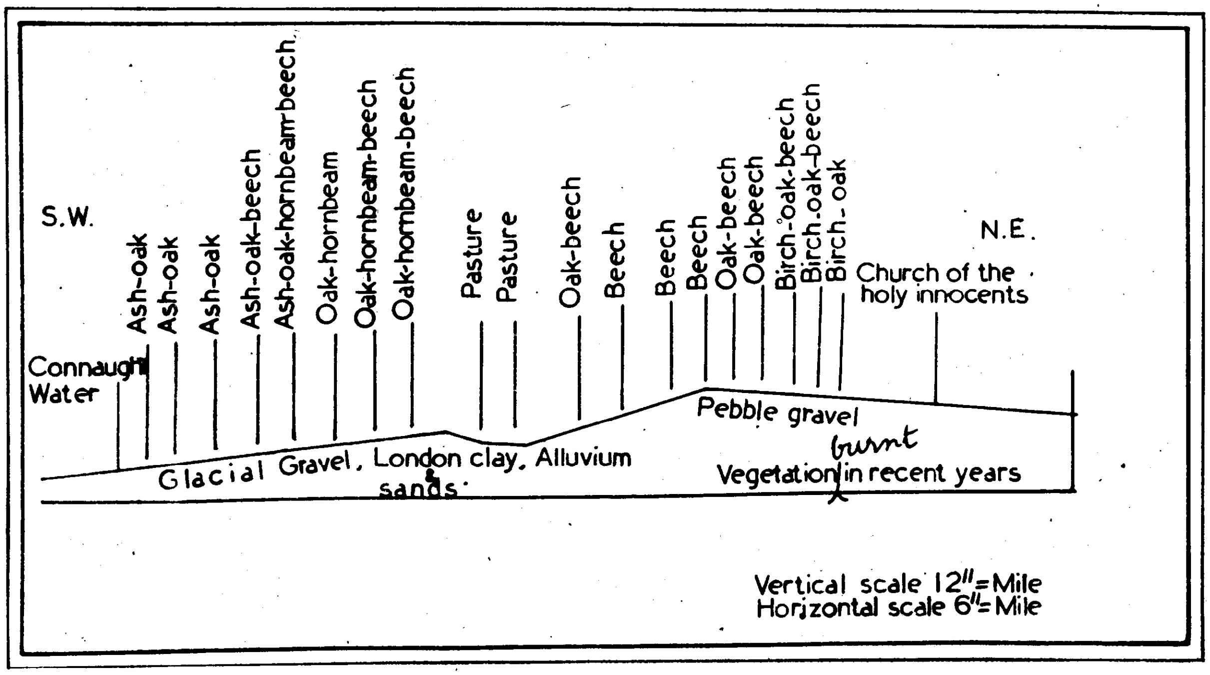

FIG. 13.—Relation between the distribution of tree communities and surface geology in the Epping Forest.

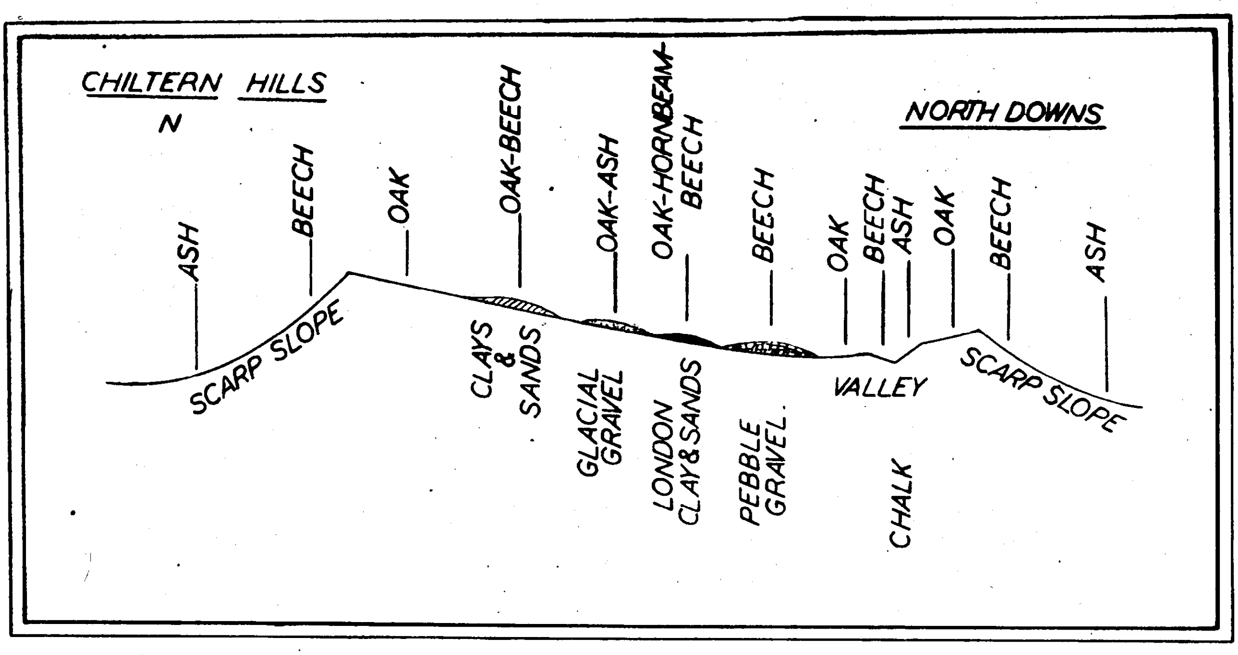

FIG. 14.—A diagramatic sketch of the London Basin showing the relation between the distribution of main tree communities and main geological features in the areas studied.

TABLE 7

Percentage distribution of trees around quadrats and soil conditions along a transact on the escarpment and dip slope at Box Hill.

Slope	Scarp slope (Bottom to top)													
Quadrat Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Betula pubescens ..	–	–	–	–	–	–	–	–	–	–	–	Felled area.	–	–
Buxus sempervirens ..	30	50	46	81	85	65	53	30	32	50	33		–	–
Corylus avellana ..	–	–	–	–	–	–	–	–	–	–	–		–	–
Cratægus monogyna ..	–	–	–	–	–	–	–	–	–	–	–		–	14
Fagus sulvatica ..	–	–	–	–	5	10	6	–	16	25	25		20	14
Fraxinus excelsior ..	50	40	28	18	5	–	–	–	–	–	–		–	–
Quercus robur ..	–	–	–	–	–	–	–	–	–	–	–		–	14
Taxus baccata ..	–	–	–	–	5	20	40	61	50	–	41		80	57
pH ..	7·15	–	7·41	6·92	7·16	6·90	6·94	7·20	7·00	6·98	6·59	6·70	7·56	–
Base status ..	ca	–	ca	ca	ca	ca	ca	ca	ca	ca	ca	ca	ca	–

Slope	Dip slope										
Quadrat Nos.	15	16	17	18		19	20	21	22	23	24
Betula pubescens ..	–	53	60	68	Felled area and dismantled fort.	66	16	19	64	43	–
Buxus sempervirens ..	40	26	36	20		–	16	25	6	7	69
Corylus avellana ..	–	–	–	–		–	–	–	–	–	–
Cratægus monogyna ..	20	–	–	4		–	–	–	–	–	–
Fagus sylvatica ..	10	–	–	–		–	–	–	–	–	15
Fraxinus excelsior ..	–	3	–	4		–	5	6	6	7	–
Quercus robur ..	10	–	–	–		16	22	31	13	43	15
Taxus baccata ..	10	–	–	–		16	11	6	6	–	–
pH ..	–	4·46	4·86	4·61		5·82	5·72	5·32	5·70	4·63	–
Base status ..	–	1	1	1		o	o	Tr	o	1	

Slope	Valley (Top to bottom)								Valley-side (Bottom to top)						
Quadrat Nos.	25	26		27	28		29	30	31	32	33	34	35	36	37
Betula pubescens ..	–	33	Felled area.	–	–	Road.	–	5	–	–	–	–	83	93	40
Buxus sempervirens ..	47	33		11	32		20	30	37	–	–	–	–	–	–
Corylus avellana ..	–	–		–	–		–	–	–	–	–	–	–	–	–
Cratægus monogyna ..	–	–		–	–		–	–	–	–	–	–	–	–	–
Fagus sylvatica ..	2	–		–	–		–	5	19	8	55	100	9	–	140
Fraxinus excelsior ..	39	22		69	56		20	50	18	–	–	–	–	–	..
Quercus robur ..	8	11		–	–		20	10	18	55	18	–	–	–	–
Taxus baccata ..	–	–		–	–		40	–	19	37	27	–	–	7	30
pH ..	5·50	5·82		5·38	6·42		5·41	4·90	–	4·69	–	–	4·24	4·31	4·14
Base status ..	Tr	o		1	o		o	1	–	1	–	–	1	1	8

Slope	Valley (Top to bottom)					Valley floor (Bottom to top)					Dip slope				
Quadrat Nos.	38	39		40	41	42	43	44		45	46	47	48	49	50
Betula pubescens ..	36	–	Road.	–	–	–	–	–	Road.	–	40	40	25	–	10
Buxus sempervirens ..	6	–		27	12	14	12	–		40	5	–	–	–	–
Corylus avellana ..	6	–		4	–	14	24	40		–	–	–	–	–	–
Cratægus monogyna ..	–	–		–	–	–	–	10		–	–	–	–	–	–
Fagus sylvatica ..	16	100		14	6	–	–	10		27	10	5	5	40	10
Fraxinus excelsior ..	12	–		55	72	72	48	40		–	–	–	–	–	–
Quercus robur ..	–	–		–	–	–	–	–		–	10	10	25	20	40
Taxus baccata ..	–	–		–	3	–	–	..		27	25	25	30	–	40
pH ..	4·42	4·04		4·62	5·20	5·31	5·4	5·01		5·45	4·22	4·51	4·32	4·18	4·38
Base status ..	1	2		–	1	1	1	1		1	1	1	1	2	1

TABLE 8

Percentage distribution of trees around quadrats and soil conditions along a transect running N.W.–S.E. over deep valley of the dip slope (see map) at Box Hill.

	Main part of the Dip slope			North-east side (top to bottom)				Valley floor		South-west side (Bottom to top)								Main part of the Dip slope				
Quadrat Nos. ..	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Fagus sylvatica ..	4	6	33·3	31·5	47	26	10	–	–	–	–	–	–	–	–	–	–	3	2	–	–	–
Quercus robur ..	32	11	11	–	–	6	–	7	–	–	–	–	–	–	–	2	2	–	2	6	4	12
Betula pubescens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–	–	–	6
Cratægus monogyna ..	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2	15	8	6
Taxus baccata ..	24	6	22·2	62·5	29	66	70	78	24	–	–	–	–	–	–	–	–	3	2	–	–	–
Buxus sempervirens ..	40	27	33·3	6	24	–	10	..	40	50	50	24	53	42	64	30	46	40	55	50	24	45
Fraxinus excelsior ..	–	–	–	–	–	–	10	14	36	50	50	66	13	38	24	60	26	25	36	28	60	30
pH ..	4·17	4·44	4·77	4·50	4·59	4·82	5·83	7·98	7·28	8·48	7·80	8·24	8·20	7·61	5·26	7·47	6·38	5·78	5·86	4·83	5·66	4·50
Base status ..	2	1	1	1	1	1	o	ca	ca	ca	ca	ca	ca	ca	o	ca	o	o	o	1	o	1

TABLE 10

Parcentage distribution of trees around quadrats and soil conditions along a transect from Connaught Water to the Church of the Holy Innocents in Epping Forest. Interval between quadrats 50 or 60 feet.

Quadrat Nos.	25	26	27	28	29	•30	31	32	33	34	35	36	37	38	39
Betula pubescens	66	92	82	100	75	82	91	80	–	–	–	–	–	–	–
Carpinus betulus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	26
Cratægus monogyna	–	–	–	–	–	–	–	–	18	–	–	–	–	–	–
Fagus sylvatica	–	–	9	–	12	9	–	20	54	73	66	75	100	88	56
Fraxinus excelsior	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ilex aquifolium	–	–	–	–	–	–	–	–	27	27	33	25	–	12	12
Quercus robur	33	8	9	–	12	9	9	–	–	–	–	–	–	–	6
pH	4·15	3·89	3·95	4·21	–	–	4·31	–	–	–	4·15	3·85	3·62	3·99	3·68
Base status	2	2	3	2	–	–	1	–	–	–	2	3	3	3	3

Quadrat Nos.	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Betula pubescens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carpinus betulus	25	30	–	–	45	38	35	26	22	40	12	50	66	33	31
Cratægus monogyna	–	–	–	–	–	6	–	–	–	–	–	–	–	–	–
Fagus sylvatica	30	50	100	100	–	–	–	22	22	–	25	12	–	–	6
Fraxinus excelsior	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ilex aquifolium	10	20	–	–	–	6	40	26	22	30	38	24	–	33	37
Quercus robur	35	–	–	–	55	50	25	26	33	30	25	12	33	33	25
pH	3·91	3·69	3·58	3·59	4·28	–	–	4·52	4·15	4·31	–	4·59	–	4·28	4·10
Base status	3	3	3	3	1	–	–	1	1	1	–	1	–	1	2

Quadrat Nos.	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
Betula pubescens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carpinus betulus	57	50	56	26	10	18	25	16	10	–	–	–	–	–	–
Cratægus monogyna	–	–	–	–	25	25	–	4	–	9	8	18	20	16	10
Fagus sylvatica	–	–	–	–	–	–	–	40	40	20	8	–	–	8	20
Fraxinus excelsior	–	–	–	20	25	31	25	4	15	17	42	33	50	33	30
Ilex aquifolium	28	25	14	40	30	–	–	16	20	18	33	12	–	16	20
Quercus robur	14	25	28	13	10	25	50	20	15	17	8	37	30	25	20
pH	4·22	4·31	4·01	4·41	4·08	4·56	4·35	4·01	4·50	4 70	4·59	4·49	4·57	4·56	5·11
Base status	2	1	2	1	2	1	1	2	1	1	1	1	1	1	o

TABLE 9.—Percentage distribution in each area of quadrats containing seedlings of named species of trees and given types of ground flora on the two slopes at Box Hill.

	Scarp slope	*Dip slope*	
	Main dip slope	Valleys in the dip slope	
No. of quadrats examined	14	40	20
Betula pubescens seedlings ..	–	7	–
Buxus sempervirens seedlings ..	29	15	15
Fagus sylvatica seedlings ..	15	7	10
Fraxinus excelsior seedlings ..	29	30	55
Ilex aquifolium seedlings ..	–	5	–
Quercus robur seedlings ..	–	7	–
Taxus baccata seedlings ..	15	7	5
Bare areas ..	35	25	–
Chamœnerion community ..	–	10	10
Mercurialis community ..	35	7	55
Mercurialis-Urtica community ..	21	–	30
Pteridium community ..	–	10	–
Rubus fruticosus community ..	–	37	–
Urtica community ..	5	7	–

TABLE 11.—Percentage distribution in each tree community of quadrats containing seedlings of named species of trees and given types of ground flora in Epping forest.

Community	Ash-Oak-beech	Oak-horn-beam-beech	Beech	Birch-Oak-beech
No. of quadrats	12	15	12	6
Betula pubescens seedlings ..	–	–	–	–
Fagus sylvatica seedlings	17	20	–	19
Fraxinus excelsior seedlings ..	25	–	–	–
Ilex aquifolium seedlings	33	40	–	–
Quercus robur seedlings	17	–	–	50
Bare areas ..	5	20	82	–
Deschampsia flexuosa ..	–	–	–	81*
Pteridium aquilinum ..	20	33	–	81*
Rubus frutidium ..	75	55	8	19

* Co-abundant.

ANTI-TERMITE CHARACTERISTICS OF CERTAIN CHEMICALS

BY THE LATE N. C. CHATTERJEE, B. M. BHATIA AND P. N. CHATTERJEE
(Branch of Forest Entomology, Forest Research Institute, Dehra Dun)

I. FOREWORD

These experiments were carried out over a period of 4 years from 1945–47 by Mr. B. M. Bhatia (under the supervision of Mr. J. C. M. Gardner, then Forest Entomologist) and from 1948–49 by Dr. P. N. Chatterjee (under the guidance of the late Dr. N. C. Chatterjee). Dr. P. N. Chatterjee has analysed most of the data, and the manuscript has been revised by the undersigned.

The anti-termite characteristics of the following chemicals and proprietory preparations have been investigated :—(i) Creosote ; (ii) "Borlac" with sodium arsenite ; (iii) "Rentokil Timber Fluid B" ; and (iv) paraffin wax-kerosene oil solution. These results are preliminary. Some observations on the natural resistance of timbers to termite attack are also reported here.

M. L. ROONWAL,
Forest Entomologist.

II. INTRODUCTION

Odontotermes (*Cyclotermes*) *obesus* Rbr. (Isoptera, Termitidæ) is the commonest mound-building termite in the New Forest Estate, Forest Research Institute (F.R.I.), Dehra Dun (U.P.), and, indeed, in the whole of North India. It attacks mainly woody surface debris such as twigs, bark-fragments, dry leaves, grasses and cowdung ; it also attacks wood in contact with the ground and wood-work in buildings, and is a pest of agricultural crops. To reach the food supplies, under-ground tunnels radiating from the mound (the latter being the headquarters of the termite queen and the main colony), are carried long distances. From these tunnels the foraging termites come up to the surface and work under temporary earthen tunnels. This termite is active in Dehra Dun throughout the year but is most active in July and August. In the present paper are reported the results of preliminary experiments conducted at the Forest Research Institute, Dehra Dun, during 4 years (1945–49) on increasing the resistance of woods by chemicals which have shown anti-termite characteristics, *viz.* (i) Creosote ; (ii) "Borlac" with sodium arsenite ; (iii) the proprietory preparation "Rentokil Timber Fluid B" ; and (iv) paraffin wax-kerosene oil solution. These experiments, except those with the last mentioned set of chemicals, were commenced by Mr. Buta Mal Bhatia of the Branch of Forest Entomology, Forest Research Institute, who maintained observations up to 1947. From 1948, observations were made by Dr. P. N. Chatterjee who also analysed the results. Some observations on the natural resistance of woods are also reported here.

III. OBSERVATIONS ON THE ANTI-TERMITE CHARACTERISTICS OF CERTAIN CHEMICALS

Creosote.—Four pieces of bamboo, *Bambusa nutans*, each 3 feet long, were given internodal injection with a mixture of creosote and fuel oil (20 : 80). These were buried up to half the length of the piece in the 'graveyard' of the Insectary at the F.R.I. As controls, four untreated pieces were similarly buried. For the last 4 years (since December 1945) the treated pieces have remained unattacked by termites, while the untreated pieces were attacked and almost completely eaten up within 6 months.

"Borlac" with sodium arsenite.—(Formula : Borax 2·6%, lac. 7·9%, sodium arsenite 4% ; dissolved in water to make 100 c.c.). Two seasoned billets, each 12 inches long and of 6 inches girth, of *Albizzia procera* were swabbed with this solution and placed inside a termite mound in the F.R.I. Demonstration Plantation in December 1945. There was no termite attack for 9 months ; controls were heavily attacked within one month.

Rentokil Timber Fluid B.—Three unseasoned billets, each 12 inches and of 4 inches girth, of *Albizzia procera* were swabbed with this solution and exposed in April 1946, in the Insectary 'graveyard' by burying half the length of the pieces in the soil. Slight grazing by termites was observed in the third year of exposure, whereas untreated pieces were heavily attacked by this time.

Paraffin wax-kerosene oil solution.—Gravely (1945) made the accidental discovery of the utility of wax as a protection against ground termites in a camp in South India. His field party spread canvas sheets on the ground; some of these sheets had a wax-coating. One night the ground termites completely ate up the blankets, etc., which were not kept on canvas sheets; but material lying on the wax-coated sheets were not touched. To extend this observation we conducted two series of experiments. In the first series 5–10% solution of paraffin wax in kerosene oil was used, and in the second the proportion of wax was raised to 15–20% (Table 1). The treatment was done under pressure of 50–75 lb. per square inch for 15–20 minutes. The absorption of chemicals was 50–60% by weight of wood with seasoned specimens and 17–25% with unseasoned ones.

It will be seen from Table 1 that control pieces were heavily attacked by termites much earlier than the treated ones which gave longer service (over $1\frac{1}{2}$ years) in the case of the first series of experiments. Observations on the second series of experiments are still in progress; treated pieces of *Albizzia procera*, *Pinus longifolia*, *Mangifera indica*, *Bombax malabaricum* and *Dalbergia sissoo*, during a 6-month's exposure, are completely free from termite attack, whereas control pieces were attacked in the very beginning.

IV. Natural resistance of timber to termite attack

Rectangular test pieces, each $8 \times 2 \times \frac{1}{2}$ inches, of *Cedrus deodara*, *Mangifera indica*, *Cedrela toona*, *Dalbergia sissoo*, *Heritiera minor* and *Terminalia tomentosa* were placed, side by side, flat on ground in the F.R.I. Insectary 'graveyard', in September 1946. *Cedrus deodara* remained resistant to termite attack for over 3 years, i.e., till November 1949 when slight grazing was noticed. *Mangifera indica* was moderately attacked and the remainder lightly attacked. Thus, tested pieces of timber were naturally resistant in the following order:—*Cedrus deodara* for over 3 years, *Dalbergia sissoo*, *Heritiera minor* and *Terminalia tomentosa* for $1\frac{1}{2}$ years; and *Mangifera indica* and *Cedrela toona* for 8 months.

V. Summary

This note deals with the anti-termite characteristics of paraffin wax-kerosene oil solution, creosote, "Borlac" with sodium arsenite, "Rentokil timber fluid B", together with some observations on the natural resistance of various species of timber.

VI. Reference

Gravely, F. H. 1945. Paraffin wax as a protection against termites. *J. Bombay nat. Hist. Soc.* Bombay, **45** (3), pp. 439–440.

TABLE 1

Experiments on the anti-termite characteristics of paraffin wax-kerosene oil solution (A) 5–10% and (B) 15–20%. Half the length of the timber to be tested was buried in the soil

Timber used in experiment	Number, etc., of material used	Size, etc., of materials	Method of treatment (pressure in lb. per sq. inch)	Date of commencing expt.	Period up to which materials remained completely free	Month when attack (together with intensity) was first noticed	Progress of attack from the month when first noticed	How does control (untreated) materials compare with treated ones (number of control pieces same as treated)	REMARKS
				A—5-10%					
I UNSEASONED									
1. *Albizzia procera* ..	16 billets	12″ long; 4″ girth	75 lb. for 20 mts.	Sept. 25, 1948	April 1949 (7 months)	May 21, 1949 (grazing)	Heavy in the 14th month (19-11-49)	Heavy in 8 months exposure, and all eaten up in 14 months	..
2. *Dalbergia sissoo* ..	16 billets	Do.	Do.	Do.	Do.	Do.	Do.	Do.	
II SEASONED									
3. *Bombax malabaricum* ..	12 rectangular pieces	12″×2″×1″	50 lb. for 15 mts.	Do.	Do.	Do.	Moderate to-date (10-2-50) (17 months)	Heavily attacked in 3 month's exposure	..
4. *Pinus longifolia* ..	Do.	Do.	Do.	Do.	Free up to 13 months	Light attack observed in 14th month	Continues as light to-date (19-2-50)	Heavily attacked in 11 month's exposure	..
				B—15–20%					
5. *Pinus longifolia* ..	4 billets	8″ long; 6″ girth	50 lb. for 30 mts.	Sept. 3, 1949	Free to-date (19-2-50) (6 month's observation)	..	Free to-date (6 month's observation)	Practically free, except for slight grazing second month	Observation are continuing
6. *Mangifera indica*	6 rectangular pieces	8″×1¾″×½″	Do.	Do.	Do.	..	Do.	Light attack in one month; to-date, moderate	Do.
7. *Bombax malabaricum* ..	6 pieces	8″ long; 6″ girth	Do.	Do.	Do.	..	Do.	Heavily attacked in 2 months	Do.
8. *Dalbergia sissoo* ..	6 pieces	8″ long; 6″ girth	75 lb. for 30 mts.	Do.	Do.	..	Do.	Light attack in 2 months; same to-date	Do.
9. *Albizzia procera* ..	6 pieces	8″ long; 5″ girth	Do.	Do.	Do.	..	Do.	Do.	Do.

REPRINTS AND EXTRACTS

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REPORT OF THE TECHNICAL MEETING ON STANDARDIZATION OF NOMENCLATURE, TERMINOLOGY, TESTING METHODS GRADING, AND DIMENSIONS OF TIMBER

VIETNAM : *April 3–7, 1950*

Meeting at Dalat, Vietnam, 18 Delegates and Observers from seven countries, having before them the Proceedings of the First Conference on Mechanical Wood Technology held at Geneva in September 1949, as well as papers submitted by Governments in Asia, unanimously adopted recommendations for submission to the First Meeting of the Commission on Forestry and Forest Products for Asia and the Pacific to be held some time late in 1950.

The participating countries included the French Union (Vietnam, Cambodia and Laos), Indonesia, Thailand, Malaya, Hongkong, United State of America and SCAP (Japan). The papers submitted for consideration at the meeting included Grading Rules for logs and lumber, material on Nomenclature, Terminology, Testing Methods and Dimensions. These were submitted by Malaya, Indonesia, the French Union, India, Burma, Philippines, New Zealand and Thailand.

Consideration of this material along with background papers and the Report of the Mysore Conference on Forestry and Timber Utilization held in April 1949 resulted in the adoption of the following recommendations :—

A. NOMENCLATURE

1. The Conference recommends that the participating countries should group their timbers into five categories. These should be as follows :—

> Teak (Tectona grandis)—Conifers—Primary (durable) Hardwoods—Secondary (semi-durable) Hardwoods and General Utility Hardwoods.

Primary Hardwoods are heavy constructional timbers that will normally last more than 5 years if used in an untreated condition in contact with the soil in termite infested areas. Secondary Hardwoods are also generally suitable for heavy construction but must be treated with preservatives if they are required to last more than 5 years in contact with termite infested soil. General Utility Hardwoods are those relatively light timbers that are in General use for interior construction and purposes such as packing cases, sheltering, etc.

2. The Conference recommends that countries agree to send to the FAO Regional Office at Bangkok a list of the trade names of their commercial timbers classified as far as possible as recommended in the first resolution. An appendix to this list should contain details of the density durability, colour, and ease of sawing of each commercial timber.

3. The Conference recommends that timbers of similar characteristics should be grouped under one trade name.

B. TERMINOLOGY

1. The Conference agrees to the definitions of defects and of the more important terms used in the timber trade that are set out in the Malayan Grading Rules, with the proviso that they may submit additional definitions and amendments to the FAO Regional Office at Bangkok for incorporation in this list if agreed upon at a future Conference.

C. TESTING METHODS

1. The Conference agrees with the Resolutions regarding methods of timber testing passed at the First Conference on Mechanical Wood Technology at Geneva in September 1949 but recommends :—

(*a*) That the cross sectional dimensions of test pieces shall be restricted to 2×2 cm. or 5×5 cm.

(*b*) That the moisture content of test specimens in an airy-dry condition shall be 15 per cent, plus or minus 2 per cent based on weight when oven dry, and that the results shall be published as obtained at the time of of the test.

(c) That tests shall be made as far as possible within the range of 25°C plus or minus 3°.

(d) That the tension perpendicular to grain test shall not normally be carried out.

2. The Conference is desirous of setting up standard methods of making moisture-strength and temperature-strength adjustments and with this object in view, proposes to study the recommendations made at the Timber Mechanics Conference held at Ottawa in 1948.

3. The Conference recognizes the great importance of achieving, as much uniformity as possible in the methods of selection of test material, and proposes an exchange of information through the FAO Regional Office in Bangkok so as to obtain if possible complete uniformity in selection methods within this region.

4. The Conference agrees that no suitable equipment exists in any of the regional laboratories for the testing of abrasion, it recommends that close touch be kept with any new developments which may be made in respect of this test.

5. The Conference recommends that if any laboratory is to undertake tests on plywood or similar Material a study should be made of the standard methods set out by the American Society for Testing Materials in their A.S.T.M. D.805-47. Furthermore it recommends that close attention should be paid to the work being carried out at Dehra Dun, India.

6. The Conference recommends that an exchange of information on methods of carrying out durability tests (graveyard) should be conducted through the FAO Regional Office at Bangkok as it is clearly very desirable that there should be Standardization of such tests.

D. GRADING

1. *Teak.*—The Conference recommends that the Burma Grading Rules should be adopted for the export of teak squares, but recognizing that there are differences in the quality of teak from different countries, considers that no agreement can be reached at present regarding that of very high quality and sawn teak for special purposes. Delegates agreed to forward their specifications for teak for high quality and special purposes, to the FAO Regional Office at Bangkok so that studies can be made with the object of attaining a greater degree of standardization.

2. *Conifers.*—The Conference considers that as there is very little export trade in conifers there is at present no need for standard grading rules for this type of wood, particularly as there is such a great divergence in the type of coniferous wood growing in these regions. But it recommends that a study be made of the problems involved in the grading of such timbers.

3. *Hardwood Logs.*—The Conference recommends that the North Borneo Standard Grading Rules shall be accepted as a basis for the grading of hardwood logs for export. It proposes that four grades shall be established, and that, after a comparison with existing rules of other countries in this region has been made at the FAO Office at Bangkok, it recommends that a set of standard rules for the export of hardwood logs shall be drawn up for presentation at a future Conference. It suggests that these rules shall be as clear and simple as possible.

4. *Hardwood Lumber.*—The Conference recommends that if any country of this region is to start exporting sawn hardwoods it should grade according to the Malayan Grading Rules and that those countries, who already have an export trade in sawn hardwoods, should study these rules and conform to them as closely as possible. However, it invites countries to make a comparative study of the method used in the Malayan Grading Rules with that developed in France. It is noted, however, that the Philippine Islands wish to retain their rules for grading Philippine Mahogany for export and that North Borneo does not wish to change its existing rules at present.

E. TRAINING OF GRADING INSPECTORS

1. The Conference recognizing the importance of the proper training of timber grading inspectors recommends that arrangements for the training of such inspectors in Malaya or other countries shall be made either directly or through the facilities of the FAO Office at Bangkok.

F. DIMENSIONS

1. The Conference agrees that the metric system of measurement of timber has

advantages over all other systems but cannot recommend the general adoption of this system at present. However, it suggests that in the region only cubic meters and cubic feet be used to record the volume of timber, and requests the FAO Bangkok Office to draw up a table for converting dimensions in feet and inches to meters and centimeters.

2. The Conference recommends that all countries send to the FAO Office at Bangkok lists of the standard dimensions of timbers for export and requests this Office to draw up a table including all these dimensions, so that, if possible, some common standards may eventually be evolved.

3. The Conference recommends that all timbers for export should generally be cut oversize to allow for shrinkage.

SIGNED AT DALAT, VIETNAM, THIS SEVENTH DAY OF APRIL 1950.

For the Delegates :	For the Director-General FAO and the Director of Division of Forestry and Forest Products FAO.
M. M. BOUCAUD, *Chairman.*	
A. V. THOMAS, *Rapporteur.*	M. A. HUBERMAN, *Secretary-General.*

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FREEZING POINT OF MILK AND ITS APPLICABILITY TO DETECT ADULTERATION OF MILK

BY NOSHIR N. DASTUR

(Dairy Bacteriologist, Indian Dairy Research Institute, Bangalore)

Common tests like fat and solids-not-fat usually applied for the detection of adulteration of milk with water allow a considerable amount of adulteration to take place. This is largely due to the fact that pure milk shows great variation in composition, and also because buffalo milk which is richer in total solids than cow milk is used freely for adulteration. A method that will permit the detection of adulteration with very small quantity of water will, therefore, prove useful and help to check this evil which is widespread in the urban centres. This method should be such that it can be used with cow and buffalo milk without creating ambiguity.

A test which is finding greater use for quality control work is the freezing point of milk. The freezing point depression of milk is produced by constituents which are in solution in the milk serum, the most important of which are lactose and chloride. These together account for nearly 75 per cent of the observed depression in freezing point. The amount of lactose and chloride in milk are so adjusted by nature that any increase in one results in a corresponding decrease in the other and vice versa. It is largely for this reason that milk has such a constant freezing point. Constituents like fat and casein which are not in true solution in milk do not contribute anything to the observed value. This makes the test independent of the most variable factor in milk, namely, its fat percentage, and so useful for detecting adulteration. A series of exhaustive investigations with the milk of western breeds of cattle have shown that the freezing point depression is the most constant physical property of milk and is not affected by such factors as naturally occurring low solids-not-fat or any hereditary and environmental factors. The minimum depression now utilized for legal purposes in western countries is 0·530°C. Application of this test in India can therefore be expected to furnish a remedy for the difficulties already mentioned. Before this can be done, it is necessary to find out the freezing point of large number of cow and buffalo milk samples, and likely factors which may influence the value. A detailed study was therefore taken up recently at this Institute under a scheme financed by the Indian Council of Agricultural Research. In the following a summary of important results is given.

The freezing point of milk can be determined by using different techniques but for analytical work the determination is always done with the Hortvet Cryoscope. The apparatus consists of a thermos flask in the centre of which is kept a glass tube containing the sample of milk. Surrounding this tube is a metal tube with a very small air gap in which is put some alcohol to make an even contact. The flask contains ether in which the metal tube dips. In the tube containing milk a special thermometer is kept which reads between the range +1° to −2°C. The thermometer should be of guaranteed accuracy and capable of reading to 1/1000 of a degree. When air is blown through ether, due to evaporation of ether, the temperature of milk begins to fall. Actually the milk is super-cooled to about −1°C. At this stage a tiny crystal of ice is introduced to start freezing when the temperature begins to rise and reaches a steady value. This is taken as the freezing point of milk. When using the apparatus a constant check is kept over the accuracy of the thermometer. The reading obtained is not the true freezing point of milk as the apparatus gives a value which is lower by 0·015°C. However, according to accepted standard no attempt is to be made to correct the observed reading.

MINIMUM FREEZING POINT OF MILK

Trials were first carried out with samples of milk of known purity to find out the average value for freezing point and the likely variations. For this purpose nearly 560 composite samples of milk from Gir, Sahiwal, Sindhi, Tharparkar and cross-bred cows, and 200

samples of Dharwar and Murrah buffalo milk produced in the Institute farm were analysed over a period of 18 months. The average freezing point of cow milk samples was $-0\cdot548$°C, and that of buffalo milk $-0\cdot549$°C. Over 97 per cent of all the samples examined show freezing point depression greater than $0\cdot530$°C, and so this value can be taken as the minimum limit for prescribing legal standards. In the case of cow milk nearly 96 per cent of the samples had freezing point within the range of $-0\cdot531$°C, to $-0\cdot560$°C. Buffalo milk samples show a wider scattering, only about 81 per cent of the samples lying within the range noted above.

The above results were obtained under Bangalore conditions, but to verify them nearly 300 samples of pure milk were collected from different farms in India and tested by this method. The samples were preserved with mercuric perchloride added at the rate of $0\cdot075$ per cent. By this method it was possible to preserve milk over a month. The observed freezing point was corrected by $-0\cdot200$°C, as the preservative added lowers the freezing point. The results again confirmed that the minimum depression for milk can safely be taken as $0\cdot530$°C.

EFFECT OF VARIOUS FACTORS ON THE FREEZING POINT

It is well known that the composition of milk is affected by several factors, e.g., the breed, individuality, season, stage of lactation, feed, etc. The effect of some of these factors was therefore studied with a view to find out how they will affect the results of freezing point test.

(i) *Breed of the animal.*—Freezing point of milk of cross-bred, Gir, Sahiwal and Sindhi cows, and Murrah buffaloes were determined. The average freezing point depression was within the very narrow range of $0\cdot546°$ to $0\cdot549°$, thus indicating that not only the breed of the animals had no marked effect on this value, but also that cow and buffalo milks give the same average value.

(ii) *Individuality of animals.*—A further study was carried out involving the analysis of nearly 580 samples collected from individual animals of Sindhi and Murrah breeds. The average freezing point was $-0\cdot549$°C, and nearly 96 per cent of samples gave freezing point depressions greater than the minimum value of $0\cdot530$°C. The test is therefore equally useful, both for mixed milk samples and for samples from individual animals.

(iii) *Freezing point of colostral milk.*—Colostrum gives a greater depression than normal milk, the average being $0\cdot580$. This larger depression in the freezing point will not in any way interfere with the application of this test for legal work, as for quality control only the minimum value is of importance.

(iv) *Effect of season.*—The values for the freezing point of milk from different breeds of animals studied over a period of one year did not reveal any change which could be ascribed to the change in the seasons.

(v) *Effect of separation and boiling.*—Separated milk, prepared from the same samples of whole milk give identical freezing point. This, as already indicated, is due to the fact that milk fat which is in the form of an emulsion does not contribute anything towards the observed freezing point depression. Heating milk to pasteurization temperature had no effect on the freezing point. Boiled milk shows greater depression than raw milk and this value does not change on storing the heated samples.

(vi) *Effect of preservatives.*—Preservatives enter into solution in the milk and, therefore, markedly alter the freezing point, the change depending on the nature of the preservative and quantity added. It is, therefore, desirable that samples to be tested by this method should not contain any preservative, and if at all they have to be stored, they must be kept in a refrigerator. If any preservative has been used its nature and amount should be known so that a correction can be applied for it.

Addition of preservatives and other substances like sugar, even in small quantities, markedly lowers the freezing point of milk. Hence if such foreign substances are added to milk their presence will not go undetected. If along with substances which lower the freezing point, say water is added to counterbalance the effect, such an addition will at once become evident when the sample is tested for the percentage of solids-not-fat and fat by the regular methods in use.

(vii) *Effect of acidity development in milk.*—Development of acidity in milk increases the

freezing point depression. It is, therefore, essential that samples tested should be wholesome with acidity not exceeding 0·19 per cent lactic acid, and in addition should not give a positive boiling test at the time of testing. If these precautions are not observed, some quantity of added water will go undetected as the developed acidity has a tendency to mask the effect of such addition.

DETECTING OF ADULTERATION WITH WATER

Experiments carried out in the laboratory show that addition of three per cent of water to milk is easily detected when the original freezing point of milk is not known assuming the minimum freezing point of milk to be —0·530°C. Tests carried out for fat and S.N.F. on the same samples of milk revealed the sensitivity of this test. For example a sample of cow milk gave fat 5·5 per cent, S.N.F. 9·47 per cent and freezing point —0·548°C. When adulterated with 10 per cent of water, the respective values were 4·90, 8·52 and —0·489°C. A survey of milk sold in the local market showed that nearly 75 per cent of the samples tested contained added water, though many of these gave normal values for fat and S.N.F. These results will illustrate the utility of the freezing point test for detecting adulteration with water.

It is hoped that the data presented here will help the public health authorities to prescribe this test for quality control work. Though the method is a little time-consuming and costly, it is only by the application of such a method which gives clear cut results, that the evil of adulteration can be successfully wiped out. It may also be added that like every other method the freezing point test has its weaker points, and the test should therefore be used as a supplement to the results of fat and specific gravity, and not to replace any quicker and useful tests.

SOME RECENT DEVELOPMENTS IN FOREST RESEARCH*

BY W. H. GUILLEBAUD

(Forestry Commission)

(*Presidential address to the Society of Foresters of Great Britain, at Lincoln, September 1948*)

STATISTICAL METHODS

The first subject mentioned in my previous paper was Statistical Methods. By 1935 the lay-outs of field trials in a form capable of statistical analysis was a common place in forest research, and the bad old methods of single unreplicated field plots was a thing of the past, except perhaps in the sphere of the permanent thinning plots to which I shall refer later. It is, however, the case that in the past 18–20 years there have been notable advances in the realm of statistical methods applied to forest research. I will mention only two examples. The first is the application of the factorial method 1937 (28) to our nursery experiments. In the 1930's we in this country at least were content with simple Latin square and randomized block forms of lay-out, and it was only recently that under the stimulus of Dr. E. M. Crowther of Rothamsted we began to realize what a powerful weapon the factorial technique places in our hands and how much more efficient and economical in ground and effort experiments with possibly interacting factors become when the factorial method of lay-out and analysis is employed. The scope for the employment of factorial lay-outs in plantation experiments is much more restricted, and there is a lot of work to be done to devise methods of dealing with the lay-out of plantation experiments, owing to the very irregular

* Extracted from *Forestry*, Vol. XXII, No. 2 (1948) pp. 145–146.

locality conditions ; but I have no doubt these are capable of solution if they are tackled energetically.

The other example I want to mention is the use of random sampling. The theory of random sampling is a comparatively new branch of statistics, and there are plenty of problems still waiting to be solved, but as a practical method random sampling is coming increasingly to the fore these days. I need only remind you of the Gallup Poll, for instance. We foresters with our vast areas and immense number of trees of varying shapes and sizes—each one of which is a unit when it comes to harvesting, and not a bulk material like roots or corn—are particularly in need of reliable methods of estimating the quantity of the whole from a series of small properly selected samples. It is satisfactory to know that the statisticians in many countries have been applying themselves to our problems. To quote only two examples, there are the line surveys carried out in Scandinavia to determine volumes and increments 1947 (21) and, during the war, the random sample survey of the woodlands in England, carried out under the supervision of Dr. Yates of Rothamsted. Quite recently we in the Commission have started a series of random-selected sample plots for estimating thinning yields in our young plantations, which we hope will give us useful date. There is no doubt that the random sample method is going to be an increasingly useful tool in the hands of the practical forester as well as of the forest research worker of the future.

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FOREST MANAGEMENT

Being a critical review of management practices evolved in the Indian Union in response to demands for forest products actuated by post-war conditions.

BY M. D. CHATURVEDI, B.SC. (OXON.), I.F.S.
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SUMMARY

Forest management in India continues to be inspired by the ideal of sustained yield enunciated by Dr. Brandis in 1856. Following the prescribed pattern to a fault, Indian working plans have shown resilient adaptability to changes brought about by industrial advancement actuated by two major wars. Management practices in legally constituted State forests have reacted to recent trends in management and development of silvicultural technique. Increased demand for structural timber during the post-war period ; new demands for lesser known timbers for manufacture of bobbins, matches, plywood, paper and rayon ; and the inordinate demand for firewood find reflection in recent working plans. No less important is the bearing which mechanized transport, disposal, conversion and treatment of forest produce has had on forest management.

2. The progressive realization of the role of forests in the economy of a predominantly agricultural country like India has attracted the attention of Provincial Governments to the need of the conservation of private forests and the creation of firewood and fodder reserves on waste-lands and State lands such as canal banks, railway lands, camping grounds, etc. Management of such forests is particularly designed to provide firewood to divert farm-yard manure from village hearths to village fields.

1. *Introduction.*—The sustained utilization of forest resources while ensuring their conservation in perpetuity constitutes the quintessence of forest management. To secure continuity of forests both in *space* and *time*, it is imperative that their exploitation during a given period should not exceed the amount of growth they put on (increment) in that period. The yield (trees cut annually) must, therefore, be correlated with the increment of a forest. Forest capital yields a dividend in the shape of annual increment which may be collected year after year in perpetuity. In actual practice, however, a portion of increment is left uncut (or re-invested, to use financial parlance), to build up deficient growing stock and to lay by a reserve as a provision against accidents, natural calamities and national emergency.

2. The above mentioned principle of sustained yield as originally enunciated by Sir Dietrich Brandis in 1856 when he did the first working plan of Pegu forests in Burma continues to be the keynote of the Indian working plans (2). As a result of their central control for close on half a century, the pattern laid down for working plans has seldom varied ; their underlying principles never.

3. A distinction must, however, be made between the degree of control exercised in the State and *other* forests. The standard of management obtaining in the State forests constituted under legislation enacted about 75 years ago is imbued with traditional efficiency which is neither feasible nor attainable in *other* forests which have come to attract the attention of provincial governments only during comparatively recent years.

4. Less rigid and unorthodox management has been devised for such forests comprising mostly privately owned and community forests and State tree-lands in rural areas. The management of these forests merits, therefore, special notice distinct from the technique evolved in State forests.

I. MANAGEMENT OF STATE FORESTS

5. Chief among the various factors responsible for the evolution of forest management in the State forests are :

(1) objects of management ;
(2) silvicultural technique ;
(3) demand for forest produce ; and
(4) transport, conversion and treatment.

For, the slightest variation in any of these

items must needs reflect itself in the management of a forest. A detailed discussion of these factors will indicate their cumulative influence on recent management practices developed in Indian forests.

(1) OBJECTS OF MANAGEMENT

6. The objects for which a forest is maintained by the State naturally determine its management. Thus, the maritime pine (*Pinus maritima*) forest in Landes which has for its object the supply of pit-props for coal mines must obviously be managed differently from the *chir* pine (*Pinus longifolia*) forests maintained to protect Himalayan slopes. Not infrequently the economic motif is subordinated to aesthetic considerations which justfy the retention of a tree as long as it is beautiful. Along hill slopes where protection constitutes the chief object of management, no tree may be felled, until it is dead. Roadside avenues in the tropics are managed not for profit but for the provision of shade against the blazing hot sun (4). Obviously, therefore, no tree may be felled as long as it provides shade. Plantations raised for the specific purpose of supplying firewood or tan barks, on the other hand, are clearfelled after short intervals (rotation).

7. Working plans react to the least little change of emphasis in the objects of management. Thus, with the cessation of trade relations with South Africa and consequent stoppage of the import of wattle (*Acacia decurrens*) tan bark, the management of *babul* (*Acacia arabica*) plantations is being modified in the United Provinces to meet this unforeseen demand. In the Central Provinces, accent on the provision of grazing facilities has determined the formation of pasture working circles based on periodic closures.

(2) SILVICULTURAL TECHNIQUE

8. The management of a forest is influenced to a large extent by the method adopted for its perpetuation. Various silvicultural systems such as artificial planting, natural regeneration involving manipulation of soil, its cover and canopy, vegetative propagation of the same root stock (coppice), call for different plans of management.

9. Increase in yields has been effected during recent years by the development of new silvicultural techniques in the regeneration of forests. Thus, in the Eastern States Agency (Orissa) forests, the selection system has given place to concentrated regeneration fellings. The working plans of the more accessible forests of the Keonjhar State lays down complete removal of overwood from regeneration areas. Recent strides made in the solution of the problem of *sal* (*Shorea robusta*) regeneration have not been without far-reaching effect on its management in the United Provinces. Similarly, the introduction of *taungyas** as a means of regenerating teak (*Tectona grandis*), *sal* and miscellaneous forests and the recourse to artificial regeneration in supplementing natural regeneration have been responsible for releasing mature trees which would have been otherwise retained as seed bearers and standards (1). On the other hand, the study of the price increment put on by teak in the Central Provinces has resulted in the adoption of longer rotations and smaller yields which fetch higher prices.

(3) DEMAND FOR FOREST PRODUCE

(i) *General*

10. The variation in demand for forest produce vitally affects the objects of management in response to which working plans must adjust themselves. While the demand for forest products progressively increases with the general industrial advancement of a country, its even tenor undergoes wild fluctuations by the interposition of wars. Thus, while our working plans withstood the strain of the First World War, the exigencies of the Second World War made such heavy demands on our forest resources that the prescribed sequences of fellings were honoured more in their breach than in their observance. The unlimited demand for construction timber, railway sleepers, beams, transmission poles, *ballis* (props) and producer gas charcoal soon threw most working plans out of gear.

(ii) *Post-war demand*

11. (*a*) *Timbers.*—With the cessation of hostilities, the demand for timber did not

* *Taungya* is a Burmese expression for shifting cultivation. The method was originally resorted to in artificial regeneration of teak forests in Burma by permitting cultivation of paddy and cotton on strips of land between the lines of teak seedlings. The cultivator, under this system, gets land free of rent for 4 or 5 years, as a *quid pro quo* for his labour expended on looking after the young plants. In areas where there is land hunger the bumper crops which virgin forest land yields attract sufficient men to depend upon this method as a means of regenerating forests.

diminish. Post-war reconstruction projects, house-building schemes and the provision of shelters and shops for the refugees from Pakistan have considerably stepped up the demand for timber. The situation has been further aggravated by timber being employed as a substitute for cement and iron both of which are in short supply.

12. (*b*) *Softwoods*.—The demand for matches, plywood, packing cases and tea chests has inordinately increased since Japan went off the timber market. *Semal* (*Bombax malabaricum*) and *gutel* (*Trewia nudiflora*) for which there was no demand until the twenties are now vital for the match industry. In the United Provinces, the yield of *semal* is calculated very much like Brandis calculated his yield for teak (vide appendix I). The exploitable diameter has been reduced to step up the yield. Tests carried out recently in collaboration with the Western India Match Factory have revealed that *arroo* (*Ailanthus excelsa*) is an eminently suitable species for the manufacture of matches, being superior to *semal* both in colour and strength. Working plans under revision contemplate the utilization of excess *semal* stocks during the next 30 years—a period in which *arroo* would come to supplement match wood supplies. *Semal* having been ear-marked for matches, special felling schemes have been drawn up for *kanju* (*Holoptelia integrifolia*) as the next best material for packing cases. Similarly, *haldu* (*Adina cordifolia*) is exclusively worked for the manufacture of bobbins. Bamboo (*Dendrocalamus strictus*) is used for the manufacture of paper pulp ; spruce (*Picea morinda*) and silver fir (*Abies webbiana*) for rayon ; while *hollong* (*Dipterocarpus macrocarpus*, Assam) and *hollock* (*Terminalia myriocarpa*, Assam) find their way into the plywood industry for tea chests. The demand for *salai* (*Boswellia serrata*) for newsprint has occasioned the formation of an overlapping working circle in the Central Provinces. The discovery of mulberry (*Morus alba*), which came up as a weed in the Changa Manga plantations in the Punjab and was long regarded as such, as a species suitable for sportswear, has radically changed the management of these plantations.

13. Of recent years, special attention has come to be devoted to the perpetuation of softwoods. No longer may these species be exploited without any thought for their future. Revised working plans now prescribe special measures for their artificial and natural regeneration. Softwood plantations now occupy the place of pride in some of the divisions.

14. (*c*) *Firewood*.—No single factor has affected forest management during recent years so much as the demand for firewood. Indifferent as the supplies were before, the deterioration in the movement of mineral coal has thrown an additional burden on firewood resources. Industry which until recently was geared to coal power has had to turn to firewood to keep its wheels going. The desperate situation so created would have taken an ugly turn had not some of the Provincial Governments resorted to carefully devised control of the distribution of firewood. The priority assigned to the movement of firewood has averted a firewood famine which threatened to render food unavailable in large cities.

15. The inordinate demand for firewood has proved a blessing in disguise. Distant coupes whence firewood extraction was uneconomic came to be exploited with the rise in fuel prices. Subsidiary silvicultural operations and thinnings in young crops which were often neglected due to lack of demand for their yield began to receive the attention they deserved and valueless species unfit for anything else have been utilized as firewood.

(4) TRANSPORT, CONVERSION AND TREATMENT

16. Of recent years, improved communications, mechanized transport, labour saving devices in conversion and treatment of timbers with creosote and chemicals have come to play an important role in the utilization of species considered inaccessible or valueless before.

II. MANAGEMENT OF AGRICULTURAL FORESTS

(1) BALANCED LAND-USE

17. Recent trends in some provinces which aim at developing forestry as a hand-maid of agriculture deserve special notice. The continuous encroachment of the plough resulting in the wanton destruction of village forests, more particularly in densely populated regions, such as the Gangetic basin, has completely upset the agronomical balance between agriculture, forestry, grazing grounds, habitations and

communications. The progressive disappearance of tree-lands from the country-side has compelled the cultivator to burn the bulk of his farm-yard manure which should have gone to replenish his fields. The low, if not diminishing, crop returns from impoverished fields find an easy escape in further extension of cultivation, establishing a vicious circle out of which there is no escape. What is needed in such regions is the restoration of a balanced land-use, providing each group of villages with its complement of cultivation, pastures and tree-lands (3).

(2) Fuel-fodder reserves

18. Of late, the attention of provincial governments has been focussed on the need of creating fuel and fodder reserves as a means of reconstructing the rural economy. Besides providing cheap fuel for diverting cowdung manure from village hearths to village fields, such reserves would ensure cooler temperatures, act as wind break and arrest both wind borne and fluvial erosion (5).

19. In the United Provinces, about a hundred thousand acres of wasteland have been acquired for the creation of fuel and fodder reserves. In addition, all State lands such as roadside avenues, canal banks, railway station yards, crown lands and camping grounds have been geared into an integrated scheme for supplementing supplies of firewood, fodder and timber for agricultural implements. Working plans drawn up for the management of canal plantations are being revised with particular emphasis on raising more firewood on short rotation in preference to large timber. Stretched like a ribbon, these plantations serve a densely populated and intensely cultivated area. Roadside avenues are now renovated according to working plans with a definite aesthetic bias.

(3) Private forests control

20. The prospects of quick returns being absent, private owners of forests are apt to sacrifice their capital for immediate gain. The State alone can assume the responsibility of acting as a custodian of forest wealth in the interest of the common weal. As an earnest toward the conservation of forest resources for the benefit of agriculturists, Private Forests Control Acts have been passed in Bengal, Bihar, Orissa and United Provinces. Other provinces are considering legislation on similar lines. The conservation of forest resources as a national asset is justified not only for their role in the rural economy of the country but also on climatic and physical grounds. Recent legislation in the matter of control of private forests centres around their management according to a working plan.

(4) Cultivators' own trees

21. Until quite recently, a tenant had no proprietary right in the trees which grew on his holdings. With the amendment of the U.P. Tenancy Act (No. XVII of 1939) which conferred upon the cultivator the right to own trees, the position has changed. Cultivators are being encouraged to raise a couple of *babul* (*Acacia arabica*) trees per acre. The species selected provides excellent fodder, firewood, tanning bark and timber. Being a deep rooted species, *babul* does not compete for nutriment in the upper layers of soil which support agricultural crops. Above all, its attenuated leaf-surface further reduced by lopping does not shade crops underneath to affect production. The idea has caught on and spread during the last decade. An average of two trees to an acre would account for 68 million trees in the Gangetic basin alone in the United Provinces, or the equivalent of two million acres of *babul* plantations with thirty-four trees to an acre.

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APPENDIX I

Yield regulations for the *semal* working circle in Tarai and Bhabar Estates Forests, United Provinces

Scattered throughout the tract, *semal* occurs frequently associated with other miscellaneous species. Spasmodic regeneration, which establishes itself under the protection of thorny bushes of *beri* (*Zizyphus jujuba*) is supplemented by artificial regeneration. Selection fellings are prescribed, the exploitable diameter limit being 28 inches at breast height. The yield is by number of trees.

2. To ensure the sustained supply of exploitable trees (I class over 28″ diameter), the annual yield must be placed at a figure representing the number (x) of II class trees (20″ to 28″) which pass into the I class (over 28 inches) per annum. We have thus—

$$x = 1/t\ (\text{II} - z\%\ \text{of II})$$

where,

t is the time which II class trees take to pass into I class and which, although actually 13 years* has been placed at 15 years for safety.

z represents the percentage of II class trees which disappear in t years and has been assumed to be 15% in the felling cycle of 15 years. Detailed calculations of the annual yield are given below :—

Enumerations of fit trees indicate :

I class (over 28″ diameter) —32,635
II class (20″ to 28″ diameter) —39,103

Annual yield $= 1/t\ (\text{II} - z\%\ \text{of II})$
$= 1/15\ (39{,}103 - 15\%\ \text{of}\ 39{,}103)$
$= 2{,}200$ trees approximately.

The yield, it will be seen, is based upon the passage of II class trees into I class. At the end of the felling cycle the position of class I would be :

Existing class I trees	= 32,635
Recruitment during the period	= 33,238
Total	= 65,873
Removed during the period	= 2,200 × 15 or 33,000
Balance	= 32,873

a position slightly better.

* Vide Volume Tables and Diameter Growth Curve for *semal* (Bombax malabaricum) Indian Forest Records, Vol. XV, Part IV, 1932, I. D. Mahendru.

EROSION IN THE SIWALIKS OR THE CHO MENACE

BY JHUNNA SINGH

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Cho menace is a phrase so well inderstood in the Province that it is unnecessary to explain it in detail. It drew attention of the Government towards the seventies of the last century ; and in the beginning of the present century the Land Preservation (Chos) Act was enacted. Though some sort of anti-erosion work has been attempted to be done all along, it was started in earnest when the work was entrusted to the Forest Department about a decade and a half ago. The Chos had and still continue to put human effort and security in—jeopardy ; the suddenness with which floods rush down these Chos strikes terror into the hearts of people. The Cho may change its course, wash away cultivated land on the banks or silt up beautiful fields all in the course of a few hours. Houses and villages have sometimes also been washed away. It has, therefore, become necessary to adopt urgent measures that the work of the Forest Department has shown to be effective. It only remains to add that Cho menace is not confined only to—destruction of land and houses but also concerns enormous quantities of water and soil which are carried down to the Sea rather than utilized for production purposes, leaving little water for storage under-ground.

2. Experience and Science has shown that all this destruction and waste is not an act of God but is primarily due to such activities of man which have accelerated the run-off of rain water by denudation of natural vegetation. The remedy, therefore, lies in adopting such measures that will retard the flow of rain water.

For dealing with run-off, the Siwalik areas can be classified into 3 topographical regions. (i) The Siwalik hills, (ii) The sloping or undulating lands at the foot of hills and (iii) The plains and level country beyond. Roughly speaking, the area of each class (lying in Punjab) has been calculated as follows :—

	Ambala Square miles	Hoshiarpur Square miles
Siwaliks hills ..	350	800
Sloping lands ..	150	200
Undulating lands	500	400
Flat plains ..	500	850

The problem of each class of land can now be considered separately.

3. The hill tract consists of friable stone which has been very deeply cut by erosion. The remedy lies in afforesting and planting with grass this area chiefly through closures supplemented by artificial sowing and planting and contour trenching in addition to which gully plugging and check damming is required to be done in the Upper reaches. Nearly 1,000 square miles of this and some of the sloping land has been closed already under Sections 4 and 5 of Chos Act and the rest of this hilly country should be closed with the least possible delay. The cost of such works is about Rs. 5,000 per square mile but on account of financial stringency much of contour trenching and check damming, etc., can be cut down to reduce the cost to about Rs. 2,000 per square mile.

4. The sloping and undulating land is more severely cut into ravines, on account of cultivation on sloping and steep lands, than any other class of land ; and the run-off of water from this area contributes at least half of the flood water in the Chos. This fact unfortunately is not realized but explains the slow progress in cho-training works despite great improvement of vegetation in the hill tract. It is here that the ravines are still increasing and making land utterly useless for man and beast. A block of 100 square miles of such ravined land exists above Sadhaura to Bilaspur (between Markanda and Somb) and a similar block above Shazadpur (between Begna and Dangri). There are others too, and all of these are rarely visited. The main works in this class of sloping and undulating land are levelling and terracing of cultivated lands mainly by bulldozers, improvement of grazing land, re-clothing of waste land, plugging of gullies, cho-training, etc., etc. The levelling of cultivated lands which forms about half of the sloping land is likely to cost about Rs. 50,000 per square mile, and—undulating lands about Rs. 25,000 per square mile. These works are essential not only to prevent both sheet and gully erosion of cultivated lands but will lead to very considerable improvement of

production if the work is taken up in time. In this area of about 1,250 square miles just about half would be waste lands. About 100 square miles of this has already been closed under section 38 of Indian Forest Act and the rest must also come under the management for rotational closures or for afforestation, to tackle the Cho menace effectively.

5. The cultivated land which succeeds and is next to the undulating land is subject to deposition of silt by Chos and subject to erosion of land along the banks. The main work required here is training of Chos and reclamation of the excessive area under them. This work would not cost more than about Rs. 2,000 per square mile and can, as a matter of fact, be done mostly by the owners themselves by proper organization in the form of Co-operative Societies. Only the technical side of the work will require to be directed by the Forest Staff.

6. In the preceding paragraphs some idea of the nature and extent of the problem involved and the work done or to be done to combat it has been given. The cost of operations has also been indicated and is briefly summarized below:—

Afforestation in Hills	Rs. 23,00,000
Terracing and levelling of sloping and undulating lands	Rs. 4,00,00,000
Plains	Rs. 27,00,000
Total ..	Rs. 4,50,00,000

It will be soon that it will be impossible for any Government to spend so much money particularly when the benefits from the improvement of cultivated lands are to accrue to the owners. In the past, Government has contributed partly to the cost of these operations on private lands but that was more for demonstration purposes so that the villagers may take to it themselves. Perhaps a fair arrangement would be that all supervisory staff is paid by Government in addition to which Government may contribute 3/4th of the cost of works done in the hills ; half cost of afforestation works, etc., done in sloping and undulating lands and only a quarter of cho-training work done in the plains. Then the levelling and terracing of land must be made compulsory to be done by the owners themselves. It is strongly recommended that a Land Management Act on the lines of one framed for Ajmer and Marwara be introduced. The period of carrying out of this work may be fixed as about 15 years.

7. As regards publicity and propaganda, the activities at present are limited for lack of funds ; otherwise all means such as, exhibitions, delivering lectures and issuing pamphlets, etc., are also being employed by the Forest Department. Considerable help in this connection is being received from the Provincial Publicity Department.

INDIAN EPHEDRAS AND THEIR SUPPLY

BY D. P. SINGH
(*Divisional Forest Officer, Kulu*)

SUMMARY

Ephedras are the only source of Ehedrine Hydrochloride—a very important drug which is imported into the country after the main source of supply, viz., Baluchistan having gone over to Pakistan. The two important species of Ephedra generally met with are *E. Gerardiana* and *E. Intermedia* and belong to the family *Gnetaceae* which is close allied to Coniferæ. In Lahaul *E. Gerardiana* is the predominant species. The places where Ephedras grow are accessible and present little difficulty in collection. The cost of concentrated drug up to road head is likely to be Rs. 15 per maund and roughly about 40 tons of crude drug will be collected. It is of interest to note that a sample of Lahaul Ephedras has given 1.5% of pure Ephedrine, a very high percentage indeed.

Introduction.—Ephedras are the source of Ephedrine—Hydrochloride—a very important drug which is imported into the country in a—considerable quantity at 30–40 rupees per lb. Before partition, however, India had developed a considerable export trade in the crude drug as a result of investigations carried out by—Chemistry and Minor Forest Products Branch of the Forest Research Institute, Dehra Dun. During 1938, 450,000 lb. of crude drug was exported. As a matter of fact during the war even the manufacture of Alkoloid Ephedrine was also started on a large scale. The main supply came from Baluchistan which had developed a flourishing trade in the drugs. This main source of supply of this important drug having gone to Pakistan our country has become an importer of this drug. This is very untenable situation and it is high time that the question of supply of this drug from within the country is taken up and all sources tapped to make the country self-sufficient in this regard.

2. *Characteristics of the plant.*—*Ephedras* are Gymnosperms and belong to the family *Gnetacea*—a family closely allied to the Coniferæ. The genus is an erect, rigid, leafless shrub with green jointed stems, bearing red sweet ovoid fruits about ⅓″ long.

Two important species of the plant are met with in the Punjab hills, viz :

(1) *Ephedra Gerardiana*, Wall (Syn., E. Vulgaris, Hock).

(2) *Ephedra Intermedia*, Schrenk (Syn., E. Pachycloda Boiss).

Ephedra Gerardiana has green branchlets, internodes smooth or slightly rough, male spikes ovate, 1–3 together at the nodes; flowers 4–8 female spikes usually solitary; tubillus straight. Flowers in May–July.

Ephedra Intermedia.—Consists of glaucous branchlets internodes rough; male spike subglobose in dense whorls at the nodes; flowers about 8. Female spikes solitary, paired or whorled, tubillus twisted. Flowers in May.

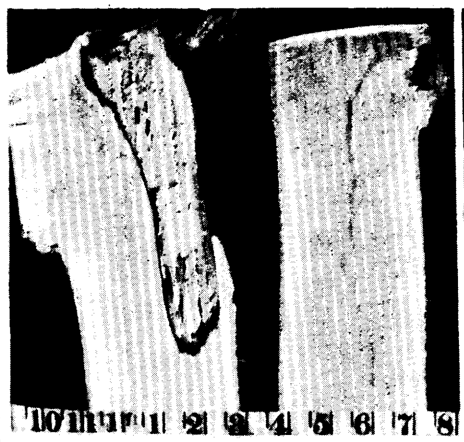
3. *Distribution and Locality.*—*Ephedras* are abundant in the drier regions of the temperate and Alpine Himalayas from Western-Tibbet to Sikkim ascending to 16,000′ *Ephedra Gerardiana* occurs commonly in Upper Kagan valley—(Pakistan) and also in Pangi, Lahaul, Kanawar (Chini and Kilba—Kailash Ranges), Shali in Simla district and Ladakh, part of India and is known locally by '*rachi*', '*khanda phag*' in Bushahr, '*asmani*', '*budagur*' and '*butshuhr*' '*chewa*' in the Punjab '*tse*', '*teapatt*' and '*trano*' in Ladakh. *Ephedra Intermedia* is found in Kanawar and Pangi only and is known by the same local names as *Ephedra Gerardiana*. In Janusar (Uttar Pradesh) the species also occurs in small quantity and is known as *tutgantha*.

In the Punjab *Ephedra Gerardiana* is found in Lahaul valley throughout the catchments of the Bhaga (Ghar valley), of the Chandra (Khokhsar valley), and of the Chandra–Bhaga (Pattan valley). It grows between 10,000′ to 14,000′ and is—distributed throughout the tract in varying quantities. The plants do not grow in compact form at one place or even in patches but is met with in scattered form amongst sandstones and rocks.

Besides Lahaul (Kulu), Pangi (Chamba) and Kanawar (Bushahr), Kashmir is another source of the drug where a limited quantity of good quality *Ephedra* is confined to Dhattamula locality. A somewhat inferior quality is also met with in Gurez and Astor areas.

PLATE I

1



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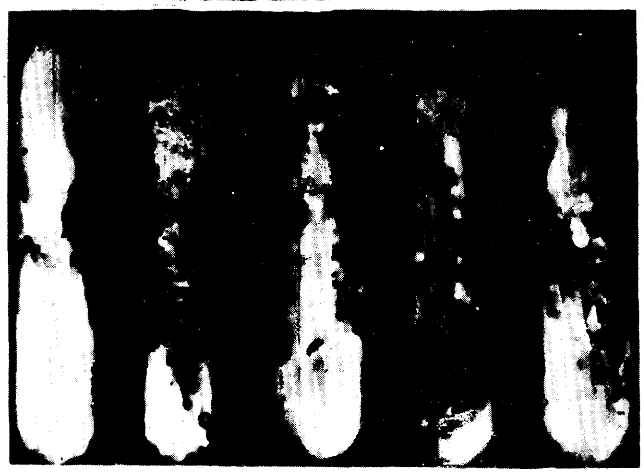

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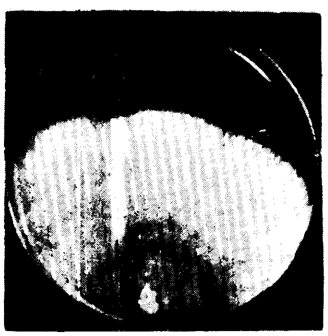

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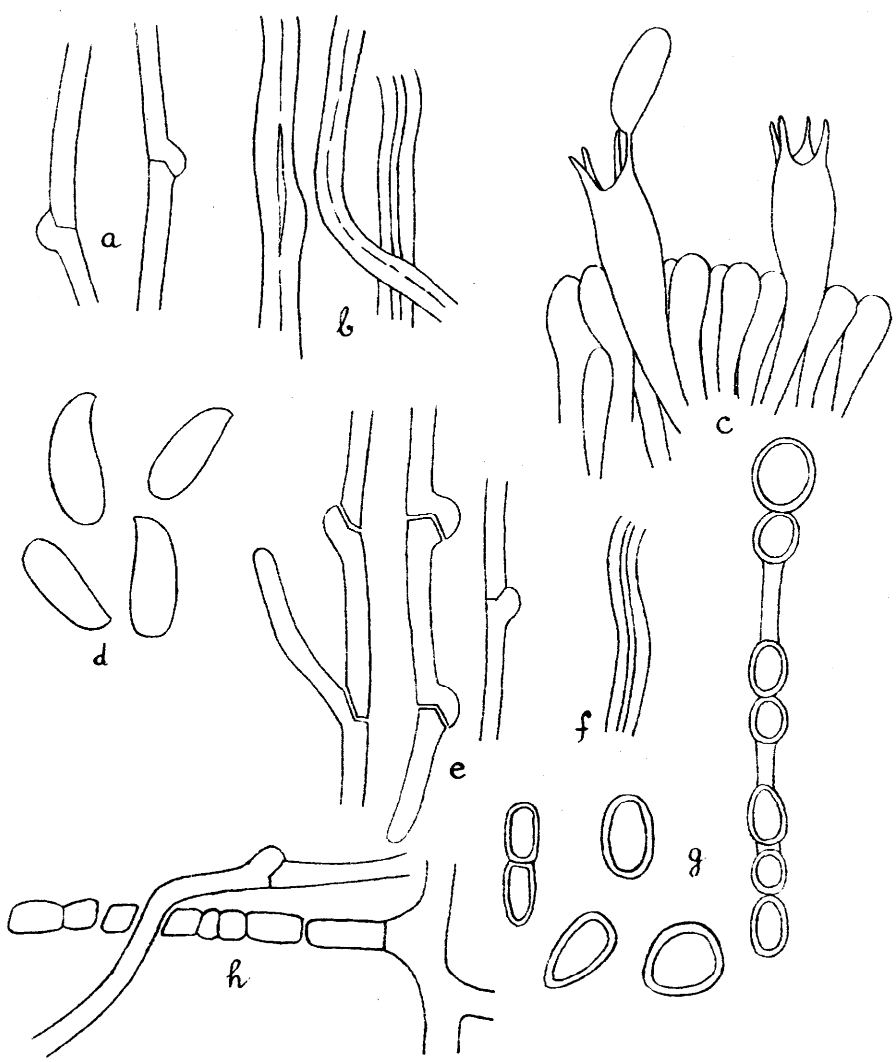
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4. *Ephedras in Lahaul.*—The places where *Ephedra* grows in Lahaul are accessible by villages paths and paths made by flocks and cattle. All these paths are linked with main village paths which ultimately join the P.W.D. roads passing through all the three valleys. Some quantities of the drug were collected from Lahaul during the war and the experience gained showed that the collection is not a difficult matter. Usually the top of the plants are cut along with the woody portions during July–September. Ephedras are able to coppice and usually the tops of the plants are cut along with the woody portions during July–September. It is then transported to motor road on mules and exported to plains where it is dried and further treated. It was observed that the carriage cost was very high and it was not found possible to compete with the drug resources from Baluchistan where also the dried Ephedra was collected at Sibi—a rail head—located several hundred miles away from the places of collection. The reason for failure was, therefore, not so much in the carriage lead alone as also other factors, e.g., defective methods of collection and indifference of local people in the drug, etc., and the fact that Ephedras occurred scattered about throughout Lahaul valley. But now that we have no other source of supply except the few places in our Himalayas there is every reason that we start the extraction of this drug from our limited resources and find out means of overcoming the difficulties. There is no doubt that our sources of the drug are in remote areas and normally considerable transport charges will have to be incurred if *crude product* was to be transported. Fortunately this difficulty is overcome greatly as the Forest Research Institute (Chemistry and Minor Forest Products Branch) has developed an easy method of preparing concentrates, which could be conveniently done on a cottage-industry form under direct supervision of the department. This will naturally provide work and income to local people besides reducing the cost on freight. The question of distant transport is, therefore, not a serious limiting factor in developing extraction of the drug from Lahaul. Further it may be noted that Ephedras can be cultivated which will greatly obviate many difficulties mentioned above.

Recently some rough estimates were made regarding cost of collection of the drug and it was observed that the cost of the collection, drying and carriage up to Kyelang was on an average about Rs. 10 per maund for the crude drug. If concentrates could be prepared at Kyelang the cost of the concentrated drug will be about Rs. 15 per maund at Manali—a Motor head 23 miles above Kulu. This figure of cost is certainly comparable with the price we are paying for Baluchistan drug. A rough survey of Lahaul areas shows that about 40 tons of the drug can be extracted from all parts of Lahaul. Assuming that 1 cwt. of crude drug gives about 1 lb. of pure drug it may safely be said that about 800 lb. of Ephedrine will be made available in the country from Lahaul alone. This will go a long way to help the country in meeting part of the demand for this drug.

It may also be added that the percentage of Alkaloids in Lahaul Ephedra is fairly comparable with any place in India or Pakistan as is evident from tests carried out by the Forest Research Institute on samples of Ephedra supplied by the writer last year from Lahaul. An interim report on one of these samples from Peokar (Bhaga valley) shows that the percentage of Alkaloids and Ephedrine is as follows.

Total Alkaloids	2·2%
Pure Ephedrine	1·5%

In this connection the writer feels it is interesting to note the results of tests carried out by Messrs. May and Baker, Ltd., on Ephedra supplied to them from Sikkim. Important extracts from the report are reproduced below:—

"On assaying the 2½ lb. (selected out of 6 lb. of total weight) however we received a pleasant surprise when we found that it contained Ephedrine Hydrochloride to the extent of 1·607%. We, therefore, feel that this is something very much worth following up and if a herb giving an assay such as this could be produced in reasonable quantities at an economic price it will place the Indian Republic in a very good position as far as the Ephedrine market is concerned."

If that could be said about Sikkim Ephedra it is doubly true and appropriate to speak about Lahaul Ephedra where we have obtained a figure of 1·5% of pure Ephedrine. The prospects are, therefore, very bright for us and we have only to make a start. Success is only next door.

PATHOLOGICAL NOTES No. 5

Contribution from the Laboratory of Forest Pathology, F.R.I.

POLYSTICTUS LEONINUS KLOTZSCH, A WOUND PARASITE

BY H. P. CHOTHIA
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Polystictus leoninus Klotzsch had so far usually been recorded as a saprophyte. In recent years, however, the fungus has been found to be a wound parasite, attacking trees in avenues and forests, in New Forest, Dehra Dun and adjoining localities after the severe frost of 1945–47.

During the last war, *Boswellia serrata* (Salai) timber used extensively for manufacturing ammunition boxes was found badly attacked by a rot. The rot which showed zone-lines was identified as due to *Polystictus leoninus* Klotzsch. From our recent field observations it appears that the fungus attacks trees of *Boswellia serrata* before they are felled. Over-mature trees contain heart-rot. Young trees with bulbous base also incorporated the fungus at the base as a wound parasite. Also the fungus attacks felled trees and sawn timber and causes decay. Salai is now used as a raw material for paper pulp. It was, therefore, thought worthwhile to work out the biology of the fungus.

Lloyd regards *Polystictus leoninus* Kl. as synonymous with *Polystictus funalis* Fr. and adopts the former name as being earlier. Miss Wakefield* states further in the communication that in the Kew herbarium it is the practice to restrict the name *P. leoninus* to the large-pored form and to call the common small-pored form as *P. funalis*. Besides this there is no difference between the two species and the species in the wide sense is *P. leoninus*. The descriptions of *P. leoninus* and *P. funalis* as given by Saccardo (1888) are essentially the same.

Hydnum gleadowii Massee was collected from Dehra Dun (India) by F. Gleadow and described by Massee (1899). Massee's description of the fungus agrees closely with those of *P. leoninus* and *P. funalis* except in the character of spores which Massee describes in *H. gleadowii* as subglobose and $5 \times 4\ \mu$ while in *P. leoninus* it is elongate and $9 \cdot 1$–$16 \cdot 7 \times 3 \cdot 2$–$6 \cdot 0\ \mu$, average $12 \cdot 0 \times 4 \cdot 1\ \mu$. The measurements of spores as given by Massee for *H. gleadowii* appears doubtful, in which case, *H. gleadowii* becomes synonymous with *P. leoninus*. Massee himself has endorsed on Kew specimens of *H. gleadowii* that the fungus is a true *Polystictus* and not a *Hydnum*.

Occurrence.—*P. leoninus* has been recorded from East Indies, New Guinea, Brazil and India. In this country, the fungus is common everywhere and has been collected from the wet zones of Northern India as well as from the dry forests of the Madhya Pradesh. The fungus is usually a saprophyte on hardwood species like *Boswellia serrata* (salai), *Shorea robusta* (sal), *Mangifera indica* (mango), and *Lannea grandis*, but may occur as an wound parasite on *Poinciana regia* (gold mohur) (Pl. I, Figs. 1 and 2), *Nerium odorum* (Pl. I, Figs. 3–4), *Cinnamomum camphora*. Fruit-bodies of the fungus in the latter case are usually found on fire scars, frost scars or on ends of broken branches.

Sporophore.—Pileus coriaceous, spongy, fibrous, sessile with broad base, convex, 4–12 × 3–8 cm. Margin irregular, curving downward towards the hymenial surface. Upper surface in young and fresh sporophores fibrous, felty, 'ochraceous buff' to 'light orange yellow' (Ridgway 1912). In old specimens it becomes more fibrous and rough with shades of 'warm buff' and 'pale orange'. Context white or light yellow, 1–$1 \cdot 5$ cm. thick. Hyphæ hyaline, thick-walled with lumen nearly obliterated, (Text-Fig. 1*b*) $2 \cdot 1$–$5 \cdot 2\ \mu$. Hymenial surface 'ochraceous buff' to 'antimony yellow' with shades of 'cinnamon buff' and 'ochraceous tawny'. Pores irregular, unequal, 12–15 per cm., pore-tubes 6–10 mm. long. Minute oily drops 'mars yellow' in shade present in pore tubes and in hymenium. Generative hyphæ hyaline, thin-walled, branched, with clamp connections (Text-Fig. 1*a*) $1 \cdot 6$–$2 \cdot 8\ \mu$ broad. Basidia (Text-Fig. 1*c*) thin-walled,

* From a communication from Miss E. M. Wakefield, Royal Botanic Gardens, Kew, to the Forest Botanist, Forest Research Institute, Dehra Dun.

hyaline, $19 \cdot 2$–$24 \cdot 0 \times 6 \cdot 4$–$8 \cdot 0$ μ with four sterigmata up to $4 \cdot 0$ μ long. Basidiospores hyaline, elongate (Text-Fig. 1*d*) thin-walled with granular contents, $9 \cdot 1$–$16 \cdot 7 \times 3 \cdot 2$–$6 \cdot 0$ μ, average $12 \cdot 0 \times 4 \cdot 1 \mu$.

Character of Rot.—*P. leoninus* produces soft white spongy rot in which brown to purple coloured zone lines develop (Pl. I, Figs. 2 and 4). On sal sapwood, the fungus produces a white spongy rot. The wood presents a mottled appearance with reddish brown zone lines. Loss in weight of the wood is about 15 per cent in 4 months.

Hyphæ are abundant in the decayed wood. They are few in the medullary rays and parenchyma but abundant in the vessels. Some of the larger vessels are filled with a fascicle of fine hyphæ. Hyphæ are hyaline, thin-walled branched with clamp connections, $1 \cdot 6$–$2 \cdot 8$ μ broad. Penetration (Text-Fig. 1*h*) between adjacent cells occurs through pits. Along the zone lines, vessels are filled with orange yellow gum-like substance. Hyphæ in the zone line are hyaline or pale yellow.

CULTURAL CHARACTERS

(*a*) *Growth characters*.—Growth (radial) $2 \cdot 0$–$3 \cdot 0$ cm. in 7 days at 24°C in dark. Mat cobwebby to subfelty, later becoming felty to floccose, white (Pl. I, Figs. 5–7). In old cultures, shades of 'yellow ochre', 'honey yellow' and 'deep olive buff' appear. Oily drops 'mars yellow' in shade appear in culture. Odour offensive. In malt agar containing gallic and tannic acids (Bavendamm 1928), diffusion zones strong, growth $6 \cdot 7$ mm. in 7 days on tannic acid, none on gallic acid. On agar containing $0 \cdot 007$ per cent gentian violet, growth moderate, medium completely discoloured.

(*b*) *Hyphal characters*.—Aerial hyphæ. Hyphæ thin-walled, hyaline, with clamp connections, branched (Text-Fig. 1*e*), $1 \cdot 4$–$2 \cdot 9$ μ broad, (*b*) fibre hyphæ thick-walled, unbranched, aseptate (Text-Fig. 1*f*) $1 \cdot 4$–$3 \cdot 0$ μ broad. Chlamydospores hyaline, thick-walled, solitary or in chains (Text-Fig. 1*g*), abundant in young cultures, rare or apparently lacking in the old, $4 \cdot 2$–$12 \cdot 6 \times 3 \cdot 3$–$6 \cdot 1$ μ. They are common in young cultures but rare in old cultures. Submerged hyphæ. Thin-walled hyphæ as in aerial mycelium. Fruit-bodies appear in culture, normal with pore-tubes spiny, yellow (Pl. I, Fig. 5).

The material examined was available in the mycological herbarium of the Forest Research Institute, Dehra Dun, collected by Dr. K. D. Bagchee, Dr. B. K. Bakshi and the writer.

Thanks are due to Dr. Bagchee and Dr. Bakshi for helpful criticisms during the work and for going through the manuscript.

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EXPLANATION OF PLATE I

Fig. 1. Sporophores of *Polystictus leoninus* on *Poinciana regia*. The branch was broken at the top and the fungus entered through it (× ⅓).
,, 2. Rot in *Poinciana regia*. Note the white spongy rot delimited from sound wood by a zone line (× ¼).
,, 3. Sporophores on an wound of *Nerium odorum* (× ⅓).
,, 4. Rot in *Nerium odarum*. Sepia coloured to black zone lines are present in the wood.
,, 5. Culture on malt agar in tubes showing fruit bodies at the top of tubes (× *1*).
,, 6. 11-days old culture on malt agar. The fungus was isolated from *Boswellia serrata*.
,, 7. 11-days old culture on malt agar. The fungus was isolated from *Poinciana regia*.

Text-Fig. 1. *a*, thin-walled hyphæ from hymenium ; *b*, fibre hyphæ from context ; *c*, basidia ; *d*, basidiospores ; *e*, thin-walled hyphæ in culture ; *f*, fibre hyphæ in culture ; *g*, chlamydospores ; *h*, penetration of a hyphæ through a pit in the tracheid wall. (All × 1,250).

SOIL pH AND FOREST COMMUNITIES IN THE *SAL* (*SHOREA ROBUSTA*) FORESTS OF THE DEHRA DUN VALLEY, U.P., INDIA*

BY G. S. PURI, M.SC., PH.D., F.G.S., F.L.S.
(*Forest Research Institute, Dehra Dun*)

A precise knowledge of ecological status of a community in an area under management is indispensible to a forester; since silvicultural operations designed to improve crop are fundamentally based on accelerating, retarding or arresting the natural succession of vegetation. It may be considered that slight variation in the soil-vegetation complex in adjoining localities produces biological changes in the pattern of a community which may not be discernible unless detailed quantitative analysis is made by transect methods. So a forest community may appear a single floristic unit, ecologically, however, it may be composed of two or more communities that may even represent different seral or developmental stages belonging to one or two different seres. The edaphic or bio-edaphic associations within a general climatic unit must be carefully established before any silvicultural prescription is applied, for experience has taught that a similar treatment recommended in an apparently homogenous community has produced quite unexpected results—often disastrous from the point of view of forest management—in adjoining compartments or even in different parts of the same compartment. To anyone familiar with *sal* community the importance of such ecological studies will be apparent as in the management of no other community in any part of the world foresters have brought forth so diverse and conflicting results with one and the same silvical treatment for obtaining natural regeneration of *Shorea robusta* (see Smythies, 1932). Our experience with teak or other forest communities in this country is not very different from that of *sal*.

It is, therefore, necessary that working plan officers and silviculturists in the first instance build up information on (1) the soil complex in relation to forest communities, (2) the stage of succession of the forest communities in the area, (3) geological and pedological conditions of the soil and its biological potentialities under present meteorological conditions and (4) the effect on the soil and plant growth of the forestry methods that are in view for management or exploitation. It is highly essential that only recommendations based on sound ecological data be carried out.

In the present paper an attempt is made to collect some information on these points from forests of the Dehra Dun valley.

Dehra Dun valley is one of the canoe-shaped, flat, longitudinal valleys—called Duns—running in an east-west direction between the main Himalayas on the north and Siwalik Hills on the south. It is nearly 50 miles long by 17 miles wide between the Jumna in the west and the Ganges in the east.

"Dehra Dun valley, although apparently a single valley, really consists of two shallow valleys, separated by a low watershed, 2,000 to 2,500 ft. above sea-level running along the Saharanpur-Dehra Dun road from Mohand Pass up to Majra, and thence in an almost straight line past the Dehra Dun cantonment to Rajpur and on to Landour" (Sen, 1941, p. 1). These shallow valleys—eastern and western—are drained by two separate river systems of the Jumna and the Ganges, respectively (Fig. 1).

Most of the reserved forests of the division occur in the Eastern Dun valley and floristically these are representative of the entire area.

By far the commonest tree species in these forests is *Shorea robusta*, which forms extensive stands, often mixed with numerous broad-leaved species in the plains, and with *Pinus longifolia* at higher levels. The interesting feature of the vegetation in this region is that while *sal* is a dominant tree at most places, the forests in the adjoining areas, under apparently similar climatic conditions, may not contain any trace of *Shorea robusta*, and are entirely composed of miscellaneous species. The miscellaneous forests in adjoining localities are also different floristically.

* Paper presented at the Symposium on "The biology of *Sal* (*Shorea robusta*)" held at the Forest Research Institute under the presidentship of Mr. C. R. Ranganathan, I.F.S., President, Forest Research Institute and Colleges.

A great deal has been written on the ecological features of *sal* forests of India and available data prior to 1933 has been compiled by Champion (1933) in his memoir on *sal*. He recognizes two types of *sal* forests in the valley :—

(1) A_1 type, dry Siwalik *sal*, represented on northern as well as southern slopes in the Saharanpur division of the Siwaliks.

(2) B_3 type, moist high level alluvial *sal*, occurring at lower altitudes in the valley on deep clayey soils.

Defining the ecological status of A_1 type Champion (1933, p. 32) states that "the type is ill-defined and little more than a transition to mixed dry deciduous with *sal* absent or as a minor constituents ; in the west (Saharanpur) the *sal* practically disappears". Mobbs, quoted by Smythies (1932, p. 201) also states that in the Saharanpur Siwaliks "the climax formations may be taken as a good miscellaneous forest where the soil conditions are dry or very moist, and a *sal* or a *sal* and miscellaneous forest where the soil is of better quality and is neither too dry nor too moist". Mobb's statement refers strictly to Saharanpur forests but as these are floristically similar to those of the northern slopes of the Siwaliks this view may be extended to the latter as well.

Regarding B_3 type Champion (*loc. cit.*, p. 43) states that "in view of the virtual absence of high forest long-lived trees any better equipped to replace the *sal*—for *Eugenia jambolana* is almost the only one—the writer is of the opinion that the true climax is likewise *sal* forest, but with a higher proportion of miscellaneous species and a groupwise mixture both as regards species and age classes". Champion himself does not seem to be very clear on this point and regarded "*Sal* forests with a small admixture of a limited number of fire hardy associates, notably *Lagerstrœmia parviflora* and mainly grassy soil cover", as "unquestionably a stable sub-climax type".

Ranganathan (1949) has recently expressed the doubt in regarding the *sal* to be a climax community in this area ; since the failure in regeneration of the community over some areas has been really acute. He states that "the difficulties of natural reproduction of *sal* are so great in certain localities that they have given room for doubt whether the *sal* forest could be climax forest in those regions after all and whether its apparent dominance over extensive tracts has not been substantially assisted by biotic factors, chiefly fire".

The Dun valley forests have been greatly disturbed by man since long times and in view of their being reserved it is difficult to consider them as climatic climax or even subclimax. The effects of biotic and edaphic factors have been clearly more potent in creating these forests in their present heterogenous state than that of climate, which broadly tends to producing uniformity over large areas rather than heterogenity.

It might be considered either different types of forest in the valley are edaphic associations related to geology and soil and are prevented from progressing to next stage of succession by biotic influences, or they represent some type of stable forest that has reached its climax under the prevailing factor of climate. The economic importance of *Shorea robusta* has, perhaps, been the prime factor to believing that *sal* forests are—or should be—climatic climax in this region and this belief has unfortunately been passed on, and no attempt has been made to see the scientific basis for it. Smythies (*loc. cit.*, p. 199) rightly states that "*One has been accustomed to regard a* sal *forest as something which always has been and always will be a* sal *forest, but under certain conditions, this is, I believe, our fundamental mistake.* With fire protection we must usually regard a good quality *sal* crop as merely a stage in the progression of the area from one plant association to another". There has been so much felling, burning, shrub and weed cutting in these areas that progression of vegetation along natural lines seems to have long ceased to exist and what we find to-day is perhaps a complex of several secondary successions at places overlapping and hiding the true primary succession of forest communities.

On account of the great confusion that exists in our present state of knowledge about the *sal* community and that the "information is still scanty as to the seral stages leading up to the *sal* climax (or sub-climax)" (Champion, *loc. cit.*, p. 49), it has been considered desirable to study the Dehra Dun forests by modern ecological methods and bring out ecological factors governing the distribution of *sal* and other communities in the area. Edaphic features have been specially investigated.

The following five examples were studied :—

1. Maidan,
2. Thano,

3. Lachiwala,
4. Kansrao,
5. Asarori and

some data has also been collected from Mohand along the southern slopes of the Siwaliks.

It will be seen from the map (Fig. 1) that forests studied are along a transect running NE.-SW. from the outer Himalayas, through the valley, and across the Siwaliks to their southern side. Thus, it is attempted to sketch an ecological picture of forest vegetation along main geological features of the country.

In this investigation I have received help from many sources, and it is a pleasure to record my appreciation of assistance rendered in running transects by Mr. J. Prasad, late Central Silviculturist, Mr. N. P. Tripathi, then Assistant Silviculturist, U.P., and Messrs. Lakhmi Chand and Ganda Ram, field assistants in the Silviculture branch. Soil pH have been determined by the kind help of Dr. R. S. Gupta.

Climate and its probable effect on the development of soils and vegetation

The region studied lies in the monsoon belt and receives nearly 75% of the annual precipitation during the months of July, August and September. Out of the remaining 25%, 10% falls in June. Thus, only 12–15% of the total rainfall is distributed in the remaining eight months which, therefore, remain more or less dry.

The annual precipitation for various stations in, or, near the forests studied is given in Table 1.

TABLE 1

Station	Annual rainfall in inches	Period for which data is available
Dholkhand	39·94	1922–27
Konsrao	58·20	1933–39
Asarori	67·60	1921–39
Lachiwala	69·60	1921–39
Dehra Dun	82·50	1911–39
Thano	97·30	1923–39

Mean for all stations = 69·5 inches.

It will be seen that highest amount of rainfall occurs at Thano, on the southern slopes of the Outer Himalayas, and the lowest figures are recorded for Dholkhand, out in the plains along southern slopes of the Siwalik Hills. In the valley, rainfall varies slightly increasing from 69·6–82·6 inches per annum. The mean annual rainfall for all stations is 69·5 inches, thus these areas are neither too dry nor moist as compared to other regions.

Some details of meteorological observations taken for the years 1947–49 at New Forest observatory are given in Table 2.

TABLE 2

Month	No. of rainy days			The range of rainfall in inches on rainy days			Total monthly rain in inches for 1949	Daily temp. in F mean of min. & max. for 1949
	1947	1948	1949	1947	1948	1949		
January	5	1	3	0·05–1·11	0·02–	0·02–0·90	1·76	50–59
February	5	7	7	0·92–0·86	0·01–0·63	0·03–3·32	2·76	50–63
March	6	7	4	0·03–0·69	0·15–0·75	0·06–0·18	5·81	60·4–76
April	2	2	2	0·03–0·22	0·06–0·12	0·26–0·58	0·25	71–83·6
May	4	3	5	0·03–0·17	0·05–0·19	0·02–0·62	0·65	77·5–87·1
June	6	7	3	0·09–2·64	0·03–0·70	0·12–1·46	11·17	72–91·4
July	26	26	23	0·02–6·89	0·02–3·76	0·03–3·65	32·95	72·1–87·3
August	23	26	23	0·04–3·51	0·02·2·97	0·05–6·58	23·23	73·9–80·1
September	16	14	16	0·05–5·35	0·05–8·08	0·02–2·60	29·78	71·5–82·9
October	3	11	1	0·01–0·05	0·02–2·65	0·15	2·13	62·7–74·7
November	..	..	..	..	..	..	..	54·6–63·9
December	2	2	2	0·01–0·27	0·01–0·27	0·03–0·23	0·19	50·4–56·1
Total	108	106	90					

It will be seen that the year falls in two distinct climatic seasons, viz., July–September and October–June. In the months of July–September the number of rainy days in a month is 20–25 but in the dry period rainy days are very few. On account of these two distinct seasons when the phenomenon of leaching and evaporation alternates development in soils along one line or the other remains incomplete, although average annual rainfall may be as high as 110 inches in a year. These soils are immature and azonal, showing an ill-developed profile. On the other hand, in the Kulu Himalayas where mean annual rainfall is only 44 inches soils are pedologically more mature than those in the Dun valley. In the former region in some places podsolic types of profiles have been recognized whereas in the Dun valley nowhere one is able to recognize even the chief layers in a profile. Thus, it is the distribution rather than the total amount of rainfall that is of importance in determining the development of soils and vegetation in an area.

In his classification of forest types Champion (1938) has considered only the annual mean rainfall, which factor is perhaps, too vague for ecological classification of plant communities. Reverting again to climatic data in the Dun valley it may be stated that the minimum temperature for the month of January in the valley is 32°F and maximum record for May is 106°F in the valley and 110–115°F in plains on the southern side of the Siwaliks. In the months of July, August and September though temperatures are high, there is a good deal of humidity in the atmosphere and due to the uniform distribution of rainfall during this period there is a considerable leaching from surface layers of the soil. During the rest of the year where there is slight rainfall evaporation from the soil appears to remain high over most of the area. Under thick and closed canopies of forest trees, however, temperatures are usually lower than in the open and there humidity is also somewhat higher. In openings in the forest or under scattered trees temperatures are usually higher than under closed canopies and evaporation may then be high in the former localities.

The ratio of precipitation/evaporation (Puri, 1950) determines the trend in the development of the soil. Thus, on a uniform geological substratum or soil a high ratio of P/E brings about leaching, by which surface soils become impoverished in bases and acidic. With low P/E bases from lower layers of the soil are brought up by evaporation to the surface layer enriching it in bases and increasing its pH.

Data collected for the distribution of CaO at different depths in soil profiles under *sal* community, in open grassy tappars, and under different types of miscellaneous forest in the area by Puri and Agarwal (1950) throws interesting light on the probable effect of climate on the development of soils in the area. In most types of soil, especially in the open, or under miscellaneous species with little or no *sal* or under clearfelled or heavily felled patches in *sal* forests upper layers (0–6″) of the soil were almost always richer in exchangeable calcium. In lower layers Ca showed faint upward increase, under the effect of evaporation. On fire lines where vegetation is periodically felled and burnt exchangeable Ca in upper layers was much higher than in lower layers. Under dense canopies of *sal* with a thick undergrowth of *Clerodendron*, *Litsea* and other spp., there was a faint trend in leaching with upper layers slightly poorer in exchangeable calcium than the lower layers. At depth of 24″ or 36″ in some profiles there was a faint evidence of deposition of calcium.

Interesting differences were seen in different types of soil as well. For example, in deep clayey soils under forest leaching was more prominent and in the open such soils did not show pronounced evaporation effects. In sandy and bouldery soils, on recent river gravels, on shingle islands, or, on conglomerate rocks, on the other hand, there was a clear effect of evaporation even under a forest cover.

During the monsoons when leaching predominantly occurs surface soils both in the open and those under different forest communities showed lower percentage of exchangeable calcium.

Thus, it may be considered that dominant trend in the development of soils in most places in the Dun valley is evaporation by which surface layer of soils is enriched with exchangeable calcium. The felling or over-exploitation of forest may further increase base status of the soils. Thus, the present climatic conditions in the areas studied and human influences generally tend to promote the growth of species with greater demands on

soil minerals at the expense of non-exacting species. In the region studied sandy and shingly soils, or those derived from conglomerate rock under the present climate would allow the growth of base-rich or exacting species and only deep clayey soils would seem suitable for species with less exacting demands on soil calcium. As it has been shown (Puri and Gupta, 1950 *a*, *b*) *Shorea robusta* and some other species that commonly occur on clayey soils have smaller amounts of foliar calcium than miscellaneous species, viz., *Anogeissus latifolia*, *Terminalia belerica*, *Buchanania latifolia*, *Ougeinia dalbergioides*, etc., which have been observed to have a greater percentage frequency on conglomerate rocks. The present trend in climatic conditions, therefore, seem to favour the growth in the area of a miscellaneous forest with little or no *sal* and this effect of climate is more marked on conglomerate and shallow clayey or sandy soils. It may be that the next stage of succession of *sal* forests is some miscellaneous community with more base rich species and it seems more likely that the *sal* community in the area is not climatic climax but may represent a developmental stage.

After considering the climate and its probable effect on forest communities in the areas studied attention was next directed to geology and soils, and effort is made in the end to correlate the effects of soil and climate on the development of forest communities.

Geology, Soils and Vegetation

The main rock system in the Dun valley is boulder conglomerate of the Upper Siwalik (Tertiary) age. Interbedded with the strata of the conglomerate there occur bands of ferruginous clay, which are of variable thickness; and along the southern slopes of the Siwalik there also occur bands of sandrock. The strata of the Siwalik rocks in the areas studied dip towards N. or NNE. (Photo 1) and outcrops of both rock types may be found on the surface in the valley in adjoining localities. The matrix of conglomerate is mainly clayey or silty in which stones and boulders of various sizes and shapes are loosely embedded. At some places matrix is calcareous and along newly exposed surfaces stones and boulders are firmly cemented.

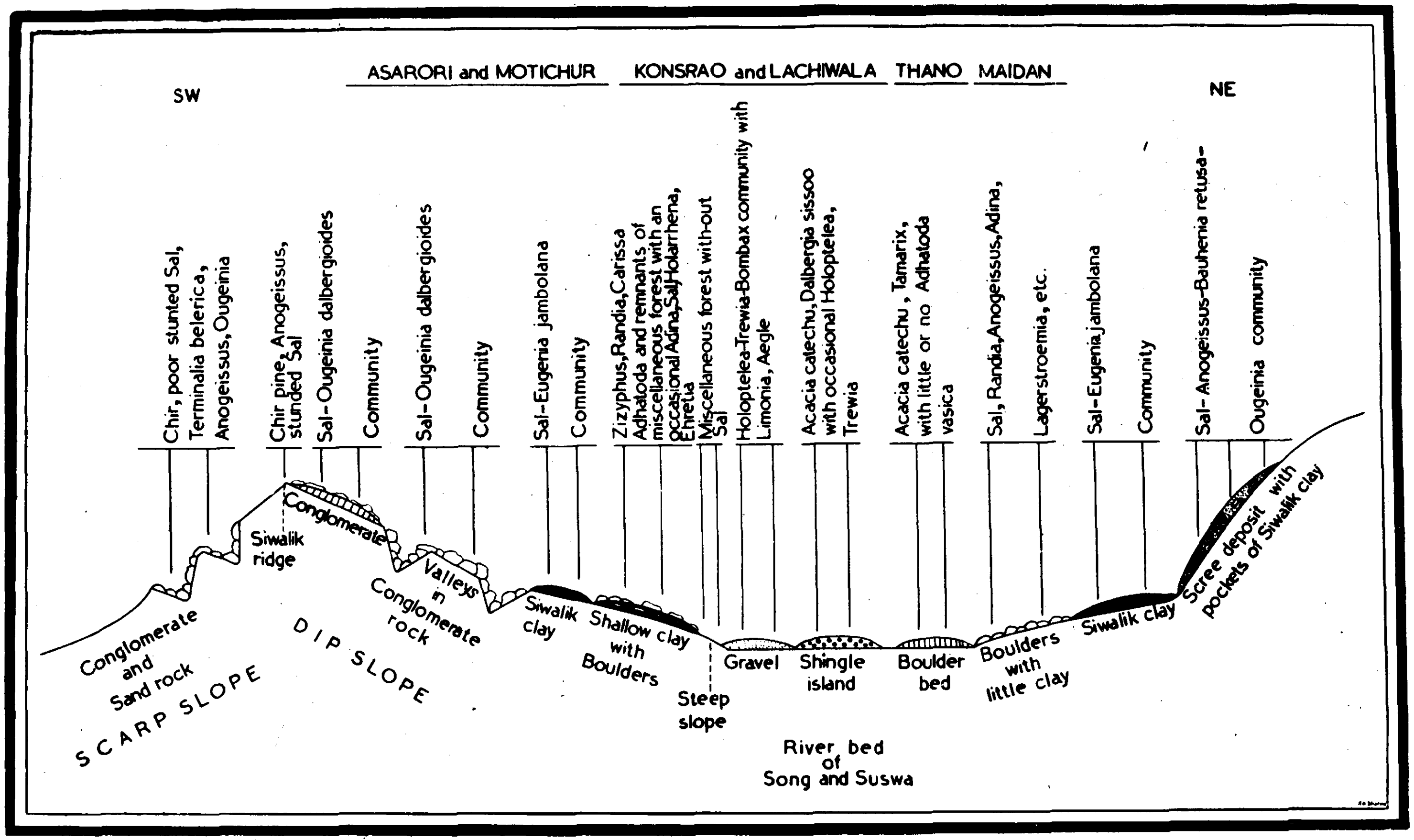
The eastern part of the valley is drained by three main rivers—Song, Suswa and Jakhan Rau—and their tributaries, which are cutting through the body of the rocks in the valley spreading boulders and stones in the entire area. Simultaneously with erosion at one place river action is forming bouldery beds, shingle island and gravel deposits at other places. Most of the tributaries locally called *raus* and even the rivers themselves in some part become dry during summer, except where bands of clay on the surface have prevented water from seeping down through porous and loose soil.

Towards the northern side of the valley the Himalayan rocks consisting of quartzites and schists are overlain by large scree deposits. The Maidan hill is formed of moraine-like scree deposit in which are embedded large and small angular stones and boulders, greatly suggesting these deposits to have a glacial origin. This possibility, however, is ruled out by the fact that there is no record of glaciation in this region in recent gelogical times and as Middlemiss (1890) suggests these deposits are perhaps, scree cones. The forests at Maidan, it may be noted, are governed by these surface deposits and underlying older rocks are too deep to have any influence on surface vegetation.

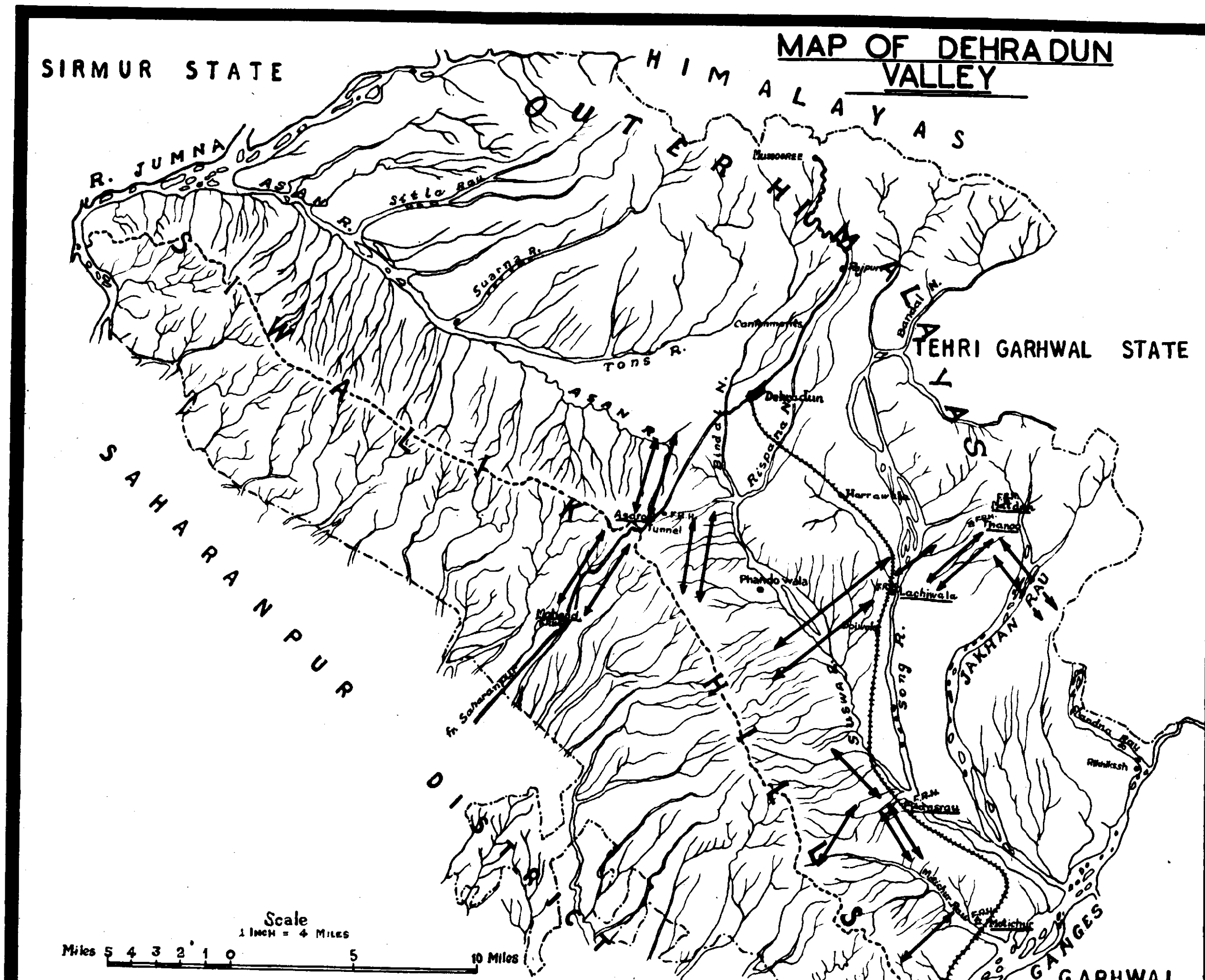
The conglomerate rock in the river valleys is either naked or only thinly capped by recent flood-plain deposits on account of which the soils are too greatly drained and quickly dry on the surface even after a heavy rain.

Thus, the following main types of soil are found in the Dun valley :—Conglomerate, ferruginous clays, clays with boulders, bouldery beds, shingle islands, gravel deposits, etc. In addition, nature of the soils on scarp and dip slopes varies according to the type of rock outcropping on the surface. There is no sequence of soil types with altitude or topographical features and more than one type may occur in adjoining localities within short distances. It is on account of these geological and soil features that there is a bewildering variety of forest types, which may merge and overlap one and other.

The vegetation was studied by running one or more transects along dip of the rock which is N.–S. or NNE.–SSW. in forest areas. All trees species, bushes and large herbs were counted in quadrats of 15–20 feet radius. The numbers were reduced to percentages. In the centre of the large quadrat one or more small quadrats of one square meter were examined and the presence or absence of small herbs and tree seedlings was recorded. Soil sample were



A diagrammatic representation of forest communities and soil types in the eastern Dun Valley .



Heavy straight lines ⟷ mark the position of transects studied during Nov. 1948–March 1949.

collected from the middle of the small quadrats or along roots of tree seedlings at depths of 0–6″. The interval between two large quadrats varied between 40–50 feet. Slope was roughly determined and other features of interest, e.g., boulders, termite mounds, humus, litter, worms, etc., where present were also recorded in the quadrats. The portions of transects studied are marked on the map (Fig. 1).

pH was determined electrometrically by shaking 2–3 gms. of air dried soil with 5 volumes of distilled water using dry battery Beckman pH meter.

Detailed data on vegetation and soil is filed in Ecology Section of the Silviculture Branch and can be readily had for reference. Salient features of vegetation are given in Tables 3, 4 and brief account that follows is based on that data :

TABLE 3—Percentage frequency of trees of given species in quadrats of 15–20 feet radius along N.–S. or NNE.–SSW. lines in various forest communities in the Dun valley

Forest community	Sal–Eugenia–Ougeinia	Sal–Eugenia	Sal–Eugenia	Sal–Ougeinia			Sal–Anogeissus–Ougeinia–Bauhenia	Miscellaneous community without sal
Locality studied	Lachiwala	Asarori	Thano	Asarori	Kansro (plain)	Kansro (hills)	Maidan	Lachiwala (steep slopes)
Number of quadrats studied	66	31	46	22	45	45	22	19
Adhatoda vasica ..	..	..	48	..	..	..	..	100
Adina cordifolia ..	..	..	4	..	..	2	23	36 (sap)
Anogeissus latifolia ..	..	..	..	..	4	9	82	..
Bauhenia malabarica ..	3	..	..	..	2	11	..	34
Bauhenia retusa ..	..	..	..	..	..	..	55	..
Carissa spinarum ..	51	6	8	40	..	11	55	26
Clerodendron infortunatum ..	65	22	82	..	..	..	9	..
Colebrookea oppositifolia ..	15	16	6	13	18	86	..	17
Ehretia lævis ..	27	22	58	9	42	64	..	26
Eugenia jambolana ..	86	90	26	18	..	2	..	42 (sap)
Ficus hispida ..	..	..	..	..	..	..	..	26
Grewia oppositifolia ..	..	..	..	..	..	..	..	26
Grewia vestita ..	32	40	8	31	..	47	5	22
Helicteres isora ..	..	..	..	..	..	..	..	52
Holarrhena antidysenterica ..	6	..	15	..	20	29	64	42
Kydia calycina ..	..	13	20	..	2	2	..	10
Lagerstrœmia parviflora ..	6	3	23	14	11	2	5	..
Litsea spp. ..	14	22	4	..	..	..	..	26
Machilus spp. ..	..	58	..	..	..	..	..	..
Miliusa velutina ..	38	3	2	..	..	..	..	..
Mallotus philippinensis ..	90	100	91	63	56	98	82	58
Murraya kœnigii ..	70	..	21	..	..	..	60	63
Nyctanthes arbor-tristis ..	..	..	..	..	..	..	55	..
Ougeinia dalbergioides ..	70	45	..	90 ..	70	82	60	..
Randia dumetorum ..	..	9	41	9	..	..	27	5
Shorea robusta ..	100	100	100	100	100	71	60	..
Terminalia belerica ..	3	..	2	9	..	..	23	..
Terminalia tomentosa ..	32	26	..	36	24	..	14	..

TABLE 4—Percentage frequency of seedlings of given species in quadrats of one square meter in large quadrats in various plant communities

Anogeissus latifolia ..	..	..	..	..	..	..	5	..
Casearia tomentosa ..	..	..	..	..	..	..	32	6
Eugenia jambolana ..	75	39	12	32	4	..	..	16
Ehretia lævis ..	12	22	17	9	16	9	..	10
Grewia vestita ..	9	27	9	9	..	..	..	12
Holarrhena antidysenterica ..	70	..	12	..	2	6	55	6
Kydia calycina ..	6	..	21	..	..	5	..	..
Lagerstrœmia parviflora ..	3	..	..	..	..	..	..	..
Litsea spp. ..	10	6	..	..	..	..	..	..
Milliusa velutina ..	..	..	..	..	..	..	..	..
Mallotus philippinensis ..	60	9	35	14	22	20	40	31
Ougenia dalbergioides ..	32	19	..	9	4	13	..	..
Randia dumetorum ..	3	..	9	18	..	..	13	..
Shorea robusta ..	94	87	76	86	62	31	18	..
Terminalia tomentosa ..	..	..	4	..	..	..	..	..

General account of the forest vegetation in the areas studied

Except on riverain soils, newly eroded areas or steep slopes with topographically immature soils or in forests which have been heavily felled and burnt the dominant forest tree in the region is almost always *Shorea robusta*. These forests are reserved and *sal* being the prize species is felled and coppiced ; so the crop at most places is pole or coppiced, which is of III–IV all India quality. *Sal* forms *Sal–Eugenia*, *Sal–Eugenia–Ougeinia*, *Sal–Ougeinia* or *Sal–Anogeissus–Ougeinia–Bauhenia* communities. All these communities on account of their having been constantly interfered with, have high percentage frequency of *Mallotus philippinensis*, varying between 56–100%.

Other trees found in all or nearly all communities are *Lagerstrœmia parviflora*, *Grewia vestita*, *Terminalia tomentosa*, etc. Common shrubs in these forests are *Carissa spinarum*, *Randia dumetorum*, *Holarrhena antidysenterica*, *Ehretia lœvis*, *Clerodendron infortunatum*, etc., the percentage frequency of these, however, varies considerably in different communities (see Table 3). Trees of *Pinus longifolia* and several other less common species also occur in *sal* forests of the northern and southern slopes of the Siwaliks.

On riverain soils and on steep slopes by the river or the hills *sal* is usually absent or very rare and the vegetation here consists of miscellaneous species. In repeatedly felled and burnt areas again *sal* is extremely rare or absent. Seedling growth of *sal* is present in all communities ; those on Siwalik clays having the greatest percentage frequency ; other tree seedlings present are *Ougeinia dalbergioides*, *Mallotus philippinensis*, *Eugenia jambolana* and *Grewia vestita*. Seedlings of *Ehretia* are also present in almost all communities. Seedlings of *Grewia vestita*, *Holarrhena antidysenterica*, *Randia dumetorum*, *Litsea* spp. are also present in some communities in small proportions.

I. MAIDAN

Scree deposits.—A community of *Sal–Anogeissus latifolia–Ougeinia dalbergioides–Bauhenia retusa* occurs at 3,000–4,000 ft. on scree deposits, at Maidan hill which is steep, and physiographically consists of spurs with scree deposits and intervening ravines with clayey soils. Main part of screes was covered by *Anogeissus*, *Bauhenia*, *Nyctanthus arbor-tristis*, *Ougeinia dalbergioides*, etc., and *sal* was usually found on ravine sides on tongues of Siwalik clays or on reassorted fine-grained deposits washed down from screes above. *Sal* were mainly large trees and poles and seedling stages were very rare. Tree seedlings and ground flora species were very rare in these forests the only seedlings present were of *Mallotus philippinensis*, *Holarrhena antidysenterica*, *Myrraya koenigii*, *Carissa spinarum*, *Casearia tomentosa* and in one or two cases seedlings of *Anogeissus*, *Aegle marmelos*, *Garuga pinnata*, *Randia dumetorum* and *Sapium* were seen.

At lower levels along the hill and on ravine sides *sal* with *Adina cordifolia*, *Elœodendron glaucum*, *Garuga pinnata* and *Mallotus* was prominent. Scattered shrubs of *Holarrhena*, *Cassia fistula*, *Carissa* were also present. At higher levels vegetation mainly consisted of trees of *Anogeissus* and *Bauhenia* ; occasionally some trees of *Terminalia belerica* and *T. tomentosa* were also present.

pH of soil samples is given in Table 5.

TABLE 5

pH of Maidan soils

pH class	–6·00	6·10–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	3	15	9	..	..	27
% of total number of soils	..	11	56	33	..	..	100

It will be seen that most of the soils have pH above 6·50 and most common trees were *Anogeissus latifolia* and *Bauhenia retusa*.

II. THANO

1. *Siwalik clays.*—From the foot of the Maidan hill there stretch into the valley thick deposits of clay overlying conglomerate. These are gently sloping towards south and are thickly forested with *sal* community, except where boulders come on the surface in stream beds.

All along in these forests *sal* is the dominant tree, the only other tree found at some places was *Eugenia jambolana*, forming *sal–Eugenia jambolana* community. Trees of *Lagerstrœmia parviflora, Kydia calycina* were present, though less frequent. *Grewia vestita* and *Adina cordifolia* were rarely seen. Regeneration of *sal* was good and both saplings and seedlings were commonly found. Some felling of *sal* trees in the past has been done and in such areas seedlings of *sal, Eugenia jambolana, Grewia vestita, Mallotus, Murraya* and *Kydia calycina*, etc., were present.

The associated vegetation with *sal* in the understorey was composed of mainly *Mallotus* and *Randia dumetorum* ; and shrubs of *Holarrhena antidysenterica, Ehretia lævis* appear to be common in felled areas. In areas with boulders and less clay *Adhatoda vasica*, with some *Carissa spinarum* was prominent. On more clayey soils *Clerodendron infortunatum* was very frequent and *Murraya koenigii* with two spp. of *Adiantum* were also seen.

All along in this area boulders and angular blocks (which have been transported from screes above) were present on the surface.

Soil pH is given in Table 6.

TABLE 6

pH of Thano soils

pH class	−6·00	6·1–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	3	23	25	10	1	..	62
% of total number of soils	5	37·0	40·0	16	2	..	100

It will be seen that 42% of the soils had pH below 6·5 and nearly 82% were below 6·80. As compared to Maidan soils these soils were comparatively more acidic and *sal* community here was very well developed.

2. *Shallow Siwalik clays with conglomerate outcrops and boulders on the surface.*—On west bank of Jakhan Rau *sal* occurs commonly associated with *Randia dumetorum, Mallotus, Limonia acidissima* and occasional *Anogeissus, Terminalia belerica, Garuga pinnata, Lagerstrœmia parviflora, Adina cordifolia* and *Elæodendron glaucum* on shallow clayey soils. Poles of *sal* are rare though seedlings were seen in plenty with occasional seedlings of *Mallotus, Limonia* (quite a few) *Cassia fistula* and *Casearia tomentosa*.

In heavily felled areas *Holarrhena antidysenterica* and *Ehretia lævis* were found. In bouldery areas with little or no clay on the surface *Adhatoda vasica* and *Carissa spinarum* were present ; but in good clayey bits *Clerodendron infortunatum* was often seen. An odd *Murraya kœnigii* was also present.

3. *River gravels and bouldery bed.*—The shallow clays imperceptibly merge into coarse gravel and bouldery soils in the bed of the stream. On older parts of gravel trees of *Dalbergia sissoo, Holoptelea integrifolia, Aegle marmelos*, some poles of *Adina cordifolia* and *Acacia catechu* were found. Here *Adhatoda vasica* and *Murraya kœnigii* were fairly common.

Younger gravels and raised river beds were profusely colonized by seedlings and small saplings of *Dalbergia sisso*. On bouldery tract with little or no gravel seedlings of *Acacia catechu* were present.

Soil pH for these soils are given in Table 7.

TABLE 7

pH class	–6·00	6·10–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	18	18	2	2	..	40
% of total number of soils in each pH class ..	..	45	45	5	5	..	100

Soils with pH above 6·80 were found on younger gravels and bouldery tracts and on older gravel deposits under *Acacia catechu–Holoptelea–Dalbergia* community soils were more acidic than on fresh gravels.

III. Lachiwala

1. *Siwalik clays*.—(*a*) A community of *Shorea robusta–Eugenia jambolana–Ougeinia dalbergioides* occurs on ferruginous clay deposits rent up by numerous dry ravines and gullies. The deposits are at places 20–25 feet thick and except in deep ravines where conglomerate rock comes on the surface the soil is clayey. The present crop of *sal* is mostly in a pole stage and cut stumps of large trees of previous crop are present. Large trees of *Terminalia tomentosa* and *Grewia vestita* are occasionally present. *Sal* usually occurs where the soil is 10–15 feet deep on spurs or at upper levels on ravine sides; bottoms, with boulders being usually occupied by other species. Seedlings of *sal*, and *Eugenia* are present commonly. Odd seedlings of *Stereospermum suaveolens*, *Kydia*, *Lagerstrœmia*, *Grewia vestita*, etc., were also seen.

In the understorey mature trees of *Mallotus*, *Miliusa velutina* and shrubs of *Murraya koenigii*, were present with saplings of *sal*. *Clerodendron infortunatum* was present in 50 per cent of the quadrats and *Colebrookea oppositifolia* was seen on bouldery soils. Seedlings of *Mallotus*, *Holarrhena antidysenterica*, *Murraya* and *Milletia auriculata* were present in fair numbers. Some seedlings of *Litsea* and *Randia dumetorum* were also seen.

By erosion of soil gullies and ravines are widening and increasing in number in the area as a result of which the soils tend to remain immature and the unstable equilibrium in the habitat seems to be favouring the persistance of a mixed community.

Soil pH are given in Table 8.

TABLE 8

pH class	–6·00	6·1–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	4	10	11	..	..	25
% of total number of soils	..	16	40	44	..	..	100

Most of the soils under this community record high pH values which is probably due to new unleached clay being constantly exposed by erosion.

(*b*) In another area *Shorea–Eugenia* community had more trees of *Terminalia tomentosa* and *Grewia vestita*.

In addition to seedlings of all understorey species recorded in the previous example there were present seedlings of *Ehretia lævis*, *Murraya koenigii* and *Carissa spinarum*. Seedlings of *Milletia* and *Bauhenia vahlii* were more numerous here. Soil at this place was shallow and boulders were found sometimes on the surface. Soil conditions as given in Table 9 also differed slightly in being little more alkaline.

TABLE 9

pH class	–6·00	6·1–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	..	20	14	2	..	36
% of the total No. of soils	..	..	55·5	39	5·5	..	100

(*c*) On heavily felled and repeatedly burnt areas along fire lines, railway lines and areas cleared for plantation and then abandoned a peculiar community with some remnants of previous vegetation and some new growth indicating retrogression and some sort of secondary succession is seen. This is clearly a biotic community and it is extremely difficult to assign its place in any successional scheme for valley forests.

The community comprises of developing trees of *Acacia catechu*, some small plants of *Aegle marmelos*, *Bombax malabaricum*, *Casearia tomentosa*, *Grewia vestita*, *Garuga pinnata*. An odd tree of *Anogeissus latifolia*, etc., was also found. Shrubs are mostly *Adhatoda vasica*, *Ehretia lævis*, *Cassia spinarum*, *Murraya kœnigii*, etc. Here tree seedlings were not found. Soil pH are given in Table 10.

TABLE 10

pH class	–6·00	6·1–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	..	2	1	6	6	15
% of total number of soils	..	..	13	7	40	40	100

Most of the soils are alkaline due probably to burning and forest clearing which bring about higher concentration of bases at the surface by releasing ash and by evaporation from lower layers of the soil thereby raising pH of surface soils.

2. *Steep slopes along river Song.*—Along the southern bank of the Song the soil comprises of calcareous tuffaceous deposits overlain by a thin cap of recent river gravels and alluvia to which some clay washed from upper parts is also present. The calcareous tuffa has weathered along steep slopes and now bears a miscellaneous community of species other than *sal*.

The most common shrubs all along the slope are *Adhatoda vasica*, *Murraya konigii*, *Mallotus philippinensis*, *Grewia oppositifolia*, *Helicteris isora*, *Flueggia microcarpa*, *Carrisa spinarum*, etc. Occasionally shrubs of *Woodfordia fruticosa*, *Limonia acidissima*, *Ficus hispida*, *Trewia nudiflora* (chiefly at lower levels on gravels) are present. Seedlings of all these species were seen. Among the tree species there were saplings of *Cassia fistula*, *Adina cordifolia*, *Casearia tomentosa*, *Eugenia jambolana* (fairly common) and seedlings of these species were also seen. Here and there odd plants of *Colebrookea oppositifolia*, *Holarrhena antidysenterica* and saplings of *Bauhenia malabarica* were present. This habitat is topographically immature and had calcareous tuffa on the surface. The pH of surface soils as given in Table 11 below was almost always alkaline.

TABLE 11

pH class	–6·00	6·1–6·80	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	..	..	1	8	11	20
% of total number of soils	..	..	..	5	40	55	100

3. *River gravels.*—Old gravel deposits adjoining northerly steep slopes along the Song bear a community of *Holoptelea–Bombax–Trewia* with a large number of miscellaneous species other than *sal*. Here *Acacia catechu*, *Limonia*, *Aegle marmelos*, with *Adhatoda vasica*, *Murraya*, etc., were present. Seedlings in this area were very few, only of *Murraya* and *Ahatoda*. Soils in this community were mostly neutral or slightly alkaline with pH varying between 7·11–7·50. This may either be due to flushing effect of calcareous tuffa from above or due to the deposition of new silt by river. The community is somewhat similar to that described from Jakhan Rau bed.

4. *On shingle spits and islands.*—There develops a community of *Acacia catechu* and depending upon the type of habitat (with or without gravel) it may allow the growth of *Adhatoda vasica*, *Murraya* or other species. On most habitats soil is extremely scanty and generally has a neutral reaction, similar to that seen in the bed of Jakhan Rau at Thano.

5. *Bouldery beds* bear a similar vegetation as on shingle islands with the difference that trees here may not attain any size or vegetation may not progress much farther.

IV. KANSRAO

1. *Koelpura Hill.*—This hill is formed of conglomerate rock overlain by and interbedded with thin bands of Siwalik clay. On NE. facing steep slope which has gradients of 1 in 2 or 3 soil is mainly bouldery with matrix of calcareous clay and is in an immature state. On SW. slope soil is shallow, clayey on spurs but in ravines boulders on the surface affect the vegetation.

Sal–Ougeinia dalbergioides community is prominent on SW. slpe, the NE. slope which appears to be a scarp slope (or face) is covered by a mixed community, without *sal*. Here trees are mainly *Anogeissus latifolia*, *Buchanania latifolia*, *Bauhenia malabarica* and at lower levels *Ficus cunia*, *Kydia calycina* occur. In depressions there may be found *Semecarpus anacardium* and *Careya arborea* with an odd plant of *Ougeinia dalbergioides*, which also affects steep slopes. Soils on the slope were calcareous with pH between 7·20–7·85 and seedlings of *sal* or any other tree were extremely rare.

On freshly cut boulder conglomerate along narrow gullies trees seedlings were seen among the first colonists and records were made in quadrats of one square meter area. Figures in the table below are percentages of total number of quadrats in which seedlings of the species were found. Total number of quadrats studied was 25.

Tree seedlings	% of total number of quadrats in which seedlings were found
Ougeinia dalbergioides ..	75
Ficus cunia	50
Woodfordia fruticosa ..	45
Carissa spinarum	30
Mallotus philippinensis ..	15
Eugenia jambolana ..	15
Bauhenia purpurea ..	5

SW. slope which is gentle but cut up in spurs and depressions, is much different from the other slope topographically, and bears *sal–Ougeinia* community. This area has been repeatedly exploited and the forest community is clearly the result of bio-edaphic factors. Among other tree species present are *Grewia vestita*, *Anogeissus latifolia*, and *Bauhenia malabarica*. Odd trees of *Lagerstrœmia*, *Kydia* and *Adina* were also present. Saplings of *Cassia fistula*, *Mallotus* and *Colebrookea oppositifolia* were constantly present and were more prominent on bouldery soil on ravine sides and escarpment. *Ehretia* and *Holarrhena* were also common especially on clayey soils on spurs from where *sal* have been felled. On ravine sides in bouldery soils vegetation of scarp type became prominent. Tree seedlings were rare, only species seen being *sal* and *Ougeinia dalbergioides*. Some seedlings of *Kydia calycina* were present in depressions. Seedlings of *Mallotus* were also seen.

Soil pH of the area are given in Table 12.

TABLE 12

pH class	–6·00	6·01–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	..	22	9	10	4	45
% of total number of soils	..	..	49	20	22	9	100

Higher pH of the soils may be due to the calcareous matrix of the conglomerate rock and the human interference of the vegetation.

2. *Plain country*.—In the area adjoining *Koelpura Hill* on plain country the conglomerate rock is close to the surface with thin bands of Siwalik clay overlying it. The area is cut up by numerous dry ravines and gullies and present a series of alternating bouldery soil and shallow clayey soil. The forest areas being within the flood level of streams have at some places, boulders and gravels mixed and often embedded in and on the surface of clays.

The vegetation is a *sal*-*Ougeinia dalbergioides* community with odd trees of *Terminalia tomentosa* found here and there. *Anogeissus latifolia*, *Buchanania latifolia*, *Albizzia odoratissima*, *Bauhenia purpurea* were each seen in one or two cases out of 45 quadrats examined. Trees of *Lagerstrœmia parviflora* were sometimes seen here and there. Some of the *sal* here are from coppiced shoots but all age classes seem to be present. The area was, no doubt, heavily exploited and termite mounds were rarely seen. This community differs from the hill vegetation in having smaller frequency of *Mallotus* and *Colebrookea oppositifolia*. The latter was only found among boulders on ravine sides. Shrubs of *Ehretia* and *Holarrhena* were also less frequent. Seedlings of *sal* were more frequent here, and those of *Mallotus* and *Ehretia* were present in some cases.

Soil pH are given in Table 13.

TABLE 13

pH class	–6·00	6·01–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	4	13	6	2	..	25
% of total number of soils	..	16	52	24	8	..	100

As compared to the previous community of *sal* which had been heavily exploited and has a low percentage of this species soils here were less alkaline.

3. *Plateau*.—On the opposite side of Konsrau Railway Station there extends a small plateau of conglomerate rock overlain by a thin cap of clay. Along the sides the conglomerate outcrops on the surface and the soil is bouldery and very shallow. The entire area had been previously heavily felled and at some places on the plateau there are no trees. The plateau is now cut up by numerous streams along the sides of which tree vegetation is developing.

The vegetation is purely artificial and contains remnants of previous crop of *sal*, *Terminalia tomentosa*, *Anogeissus latifolia*, *Buchanania latifolia* in which new saplings of *sal*, *Ougeinia*, *Mallotus*, etc., are present. Here and there saplings of *Cassia fistula*, shrubs of *Carissa spinarum*, *Holarrhena*, *Ehretia* are also present. Seedlings of *sal* and *Ougeinia* are present. It is difficult to fit in such a community of *sal* in any picture of succession in *sal* forests ; and it is purely biotic in nature.

Soil pH are given in Table 14 below.

TABLE 14

pH class	–6·00	6·10–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	..	3	2	4	4	2	15
% of total number of soils	..	20	13·3	26·6	26·6	13·3	100

While soil pH on clayey part of the plateau is less acidic, on sides where conglomerate is exposed it is usually higher.

V. ASARORI

The northern slope of the Siwalik Hills at this place is composed of chiefly conglomerate rock interbedded with thin bands of clay. The strata of the rock dip usually towards N.-NE. and NNE. the soil at some places along this slope may either be clayey or bouldery. On spurs or in steeply cut deep ravines soil is almost invariably bouldery with little or no clay, however, at lower levels clayey soils are, as a rule, present. These are usually shallow with boulders, especially in small gullies where a band of clay outcrops on the surface ; along the dip slope soils are deep and moist, and support a different type of vegetation which occurs side by side with conglomerate type of vegetation.

1. *Siwalik conglomerate.*—On the sides of deeply cut ravines and steep knife-edged ridges on boulders, with little or no soil, stunted and badly deformed *sal* forms a *sal–Ougeinia* community. Trees of *Terminalia tomentosa*, equally poorly grown, and *Buchanania latifolia* are often seen ; and other trees rarely found in the community are *Terminalia chebula*, *T. belerica* and *Lagerstrœmia parviflora*. Some saplings of *Eugenia jambolana* and *Grewia vestita* are seen on bits of clays in the bottoms and depressions. On tops of ridges chir pine is also seen. Shrubs of *Mallotus* and *Carissa spinarum* are present here and there.

Seedlings of *Shorea robusta* are common in the area studied. Seedlings of *Eugenia* were more common than those of *Ougeinia* ; *Mallotus* and some seedlings of *Randia dumetorum* and *Grewia vestita* were also present.

The soil pH are given in Table 15.

TABLE 15

pH class	–6·00	6·1–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	1	7	13	3	1	..	25
% of total number of soils	4	28	52	12	4	..	100

2. *Siwalik clays.*—At lower levels along northern slope, or, on small pockets of clay in the conglomerate rock a community of *sal–Eugenia jambolana* was present. *Sal* trees were of all age classes. Other common trees are *Grewia vestita*, and *Terminalia tomentosa*. Some trees of *Buchanania* and *Lagerstrœmia* were rarely encountered.

Shrubs of *Mallotus*, *Machilus* spp. and *Ougeinia* were commonly present. In addition, there were shrubs of *Litsea* and *Randia dumetorum* ; *Clerodendron*, *Colebrookea oppositifolia* and *Inula cappa* were rare in the area studied.

Seedlings of *sal* were common, but those of *Eugenia*, *Ougeinia* were fewer. Seedlings of *Sterculia villosa*, *Grewia vestita*, *Ehretia*, *Mallotus* and *Randia* were also seen.

The soil is clayey and cut up here and there by shallow ravines, in which boulders are often exposed.

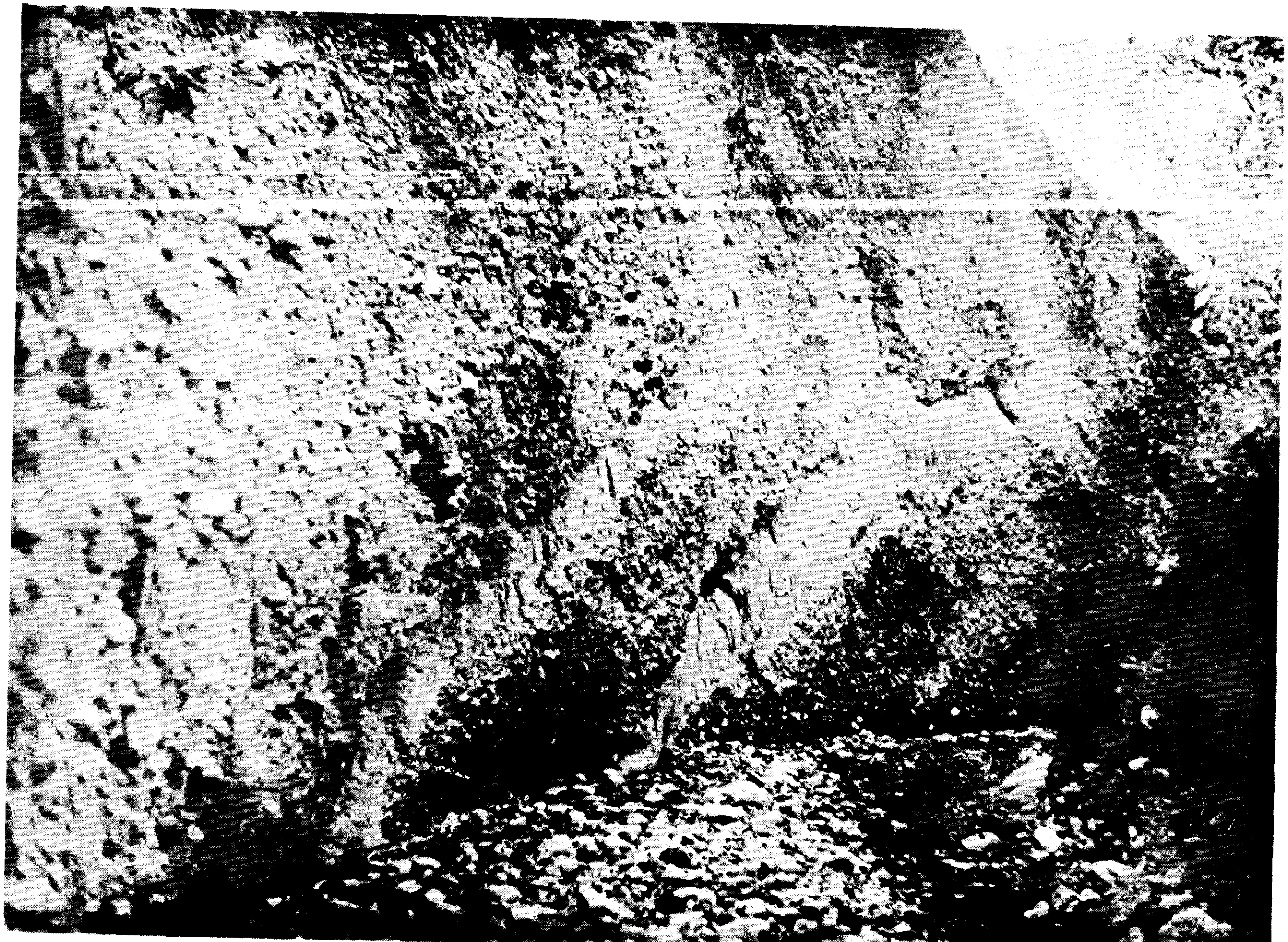
Soil pH are given in Table 16.

TABLE 16

pH class	–6·00	6·01–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total
Number of soils for each pH class ..	3	18	11	2	1	..	35
% of total number of soils	8·5	51·4	31·4	5·7	3	..	100

Rocks and vegetation on southern slopes of the Siwaliks (Saharanpur forests) ; strata of conglomerate bearing *Anogeissus, Terminalia*, etc., on top, dip towards NE. Note thin bands of clay interbedded with conglomerate bearing Sal and a small fault on right (Marked by crosses).

Photo by G. S. Puri.



A view of the scarp face of rock along a gully showing alternating strata of clay and conglomerate, dip towards NE. Note the structure of conglomerate stratum. (Saharanpur Siwaliks).

Photo by G. S. Puri.

It will be seen that most of the soils in the community are below pH 6·80 and nearly 60% have pH below 6·51.

In another small patch *sal-Eugenia* community was found in plain country on clayey soil with some boulders. Here saplings of *Cordya myxa*, *Miliusa velutina* and *Ougeinia* were recorded in one or two quadrats. *Clerodendron infortunatum* was more common.

Out of 7 samples studied 6 (85·5%) belonged to pH class 6·01–6·50 and only 1 (15·5%) was in pH class 6·51–6·80.

3. *On top of Siwalik ridge*.—Trees of *Pinus longifolia* were seen here invading the northern slopes. *Sal* and *Terminalia tomentosa* and shrubs of *Nycanthus arbor–tristis* and *Carissa spinarum* were present. pH of a few soils examined was below 6·80.

4. *Southern slopes of the Siwalik Hills*.—Along the escarpment of conglomerate, which is deeply dissected into narrow ravines and knife-edged spurs a mixed community of *Pinus longifolia–sal–Anogeissus* was found. Other trees here were *Buchanania latifolia*, *Ougeinia*, *Terminalia* spp., etc. The chir pine usually affects ridges and conglomerate rocks and seemed to have increased in numbers during the last 50 years. It is generally believed that the increase of the pine here is due to the loss of clayey soils by erosion but further work on this is in progress and its discussion may be postponed to a latter occasion.

An interesting relationship between geological features and forest species may be seen in Photograph 2. The strata of the conglomerate dip towards NE. and show interbedded thin bands of Siwalik clay. The clump of *sal* on left top in the picture occurs on clayey soil whereas the main species on conglomerate are *Anogeissus latifolia* and *Buchanania latifolia*.

Conclusions and Summary

The forest communities in the areas studied are represented diagrammatically in Fig. 2 in relation to chief geological features. It will be seen that *sal* occurs only on Siwaliks clays and conglomerates forming *sal–Eugenia* and *sal–Ougeinia* communities. On new soils, e.g., river gravels, shingle islands or boulder beds, or those which are topographically immature and contain high amount of calcium carbonates (steep slopes and scarp face, etc.) *sal* community is not present, though a solitary tree may be found locally in pockets of mature soils. On the whole, the regeneration of *sal* under the present biotic influences is best on clays. On shallow clays, with conglomerate near the surface, or in bouldery soils regeneration of this species is less frequent and on screes it is still less. On steep slopes of calcareous nature or on calcareous tuffaceous rocks there is no regeneration of *sal* and the forest there consists of miscellaneous species. The Siwalik clays are non-calcareous with 0·5–0·9% CaO but matrix of conglomerate is generally calcareous. This relationship between geology and forest communities agrees with that already sketched for larger areas by Middlemiss (1890) and Smythies (1932).

In Table 17 are given the number of soils for each pH class occurring in different forest communities. It will be seen that, on the whole, in *sal–Eugenia* communities with higher percentages of *sal* the soils were more acidic and pH of the soil showed an increase in *sal–Ougeinia* communities, especially in those with smaller percentage of *sal*. In miscellaneous communities with no *sal* pH of the soils was generally more alkaline. The data was statistically analysed* and the differences in pH for the above communities were found to be highly significant.

Over-felling and/or frequent burning of *sal* forests even on clays seems to result in increase of soil pH, and on these soils no seedlings of *sal* were found. It may seem that increase in pH of the surface soils has got something to do with whatever factors are responsible for failure in regeneration of this species.

* I am grateful to Dr. K. R. Nair, Statistician for these analyses.

TABLE 17

Forest community	Sal-Eugenia	Sal-Eugenia	Sal-Eugeinia-Ougeinia	Sal-Ougeinia	Sal-Ougeinia	Sal-Ougeinia (heavily exploited)	Felled & repeatedly burnt sal forest	Miscellaneous community *without sal*	
Locality	Asarori	Thano	Lachiwala	Asarori	Kansrao (plain)	Kansrao (hill)	Lachiwala	Lachiwala (steep slope)	Kansrao (scarp ?)
pH class				Number of soils for each pH class					
−6·00 ..	3	3	..	1	..	..	..	..	..
6·01–6·50 ..	18	23	4	7	4	..	..	..	..
6·51–6·80 ..	11	25	10	13	13	22	2	..	..
6·81–7·10 ..	2	10	11	3	6	9	1	1	..
7·11–7·50 ..	1	1	..	1	2	10	6	8	4
7·51–8·00 ..	..	..	..	..	..	4	6	11	5
Total number of soils studied in each forest community ..	35	62	25	25	25	45	15	20	9

Some pH data from 0″–6″ layer of the soil from the seedling growth of *sal* and *Eugenia* collected from these forests is given in Table 18 below :—

TABLE 18

pH class	−6·00	6·01–6·50	6·51–6·80	6·81–7·10	7·11–7·50	7·51–8·00	Total number of soils studied
	Number of soils for each pH class where seedlings were found						
Sal	6	15	23	15	1	..	60
Eugenia	3	11	7	8	..	2	31

It will be seen that greater number of seedlings of both *Shorea robusta* and *Eugenia jambolana* tend to occur in acidic soils. In alkaline soils the number of records is very low.

The data of Griffith and Gupta (1948, pp. 24, 25) for experimental plots 4 & 5 in Lachiwala tabulated below is in agreement with my results ; and it seems that higher pH in the soil are perhaps, unfavourable for the growth of seedlings of *sal*.

Data of Griffith and Gupta (loc. cit.)

	Exp. plot No. 5. Good regeneration	Exp. plot No. 4. Regeneration dies off
pH class	Number of soils for each pH class	
4·4–5·0 ..	7	4
5·1–5·9 ..	2	5
Total number of soils	9	9

For this table pH only of 0″–6″ layers of the soil are taken, which were determined by the authors during the months of August and September. My pH data, however, is for the soils collected in the months of November 1948–March 1949. It may be noted that during this period (Aug. and Sept.) there is a high rainfall in the area and low pH values recorded by Griffith and Gupta are probably due to leaching effect, however, more acidic nature of the soils in plot with good regeneration is evident even from such a small data.

The increase in pH of surface soils in the areas investigated may be due to any of the factors given below :—

(1) exposure by erosion of new unleached clays or calcareous matrix of conglomerate from below,

(2) increased evaporation from the soil by opening of the tree canopy,

(3) by increase in atmospheric temperature and light intensity in open canopy,

(4) oxidation by sun or by burning of organic matter (litter) and release of basic ash, especially from exacting species,

(5) human interference which brings into play all the above factors.

All these factors are operative in the area but their intensity is lower under dense canopy of *sal–Eugenia* on Siwalik clays which are most suitable at present for the growth and artificial preservation of this community. Although, over felling, forest clearing and burning will have less disturbing effect on clayey than on conglomerate soils, erosion effect will, however, be equally disastrous and that too will tend to bring new soils with higher pH on the surface. Moreover, if these operations are repeatedly practised their effect in the long run be very disastrous. It is for the consideration of forest officers that for exploitation and effecting natural regeneration in these forests only those methods be used that do not tend to raise pH of surface soils. For want of similar data from quality I forests in the Uttar Pradesh further discussion of these questions have to be necessarily postponed for the present.

For bringing out further relationship between forest communities and geology reference may again be made to Fig. 2. It will be seen that on riverain soils forest communities of *Acacia catechu*, *Acacia–Dalbergia sissoo*, *Holoptelea–Bombax–Trewia* occur in intimate relationship with the type of substratum. Slight variations in the floristic composition of the communities may be related to chemical composition of the reassorted soils. However, it is clear that highest type of vegetation that exists on these new soils is *Holoptelea–Bombax–Trewia* community with a larger proportion of other miscellaneous species.

It may be considered that riverain soils constitute a habitat quite distinct from that of original rock or soil in the area therefore, the vegetation types found on these also constitute a distinct secondary sere entirely unrelated to the primary sere occurring on soils formed in situ on old geological formations (including Siwalik clays and conglomerate). The only relation between the two is that they occur side by side in uniform climate. In terms of Clement riverain communities represent a secondary succession because these riverain soils are formed by erosion and subsequent deposition of new and reassorted material at places where originally there may have been Siwalik conglomerate or clay. The erosion of primary soils and deposition of secondary ones is slow and progresses in stages that may occur side by side. The vegetation on partially eroded soil would represent a stage in retrogression and where this is completed by the entire disappearance of old soil (by erosion) and later appearance of a new soil in its place by deposition there is termination of one sere and the beginning of another sere. Some species may be common between the declining sere and the developing sere but ecologically they form part of two different dynamic systems. The differences between the two would be of the same order as on two sides of a normal curve and therefore, their potentiality or capacities for further development are entirely different. For example, *Acacia catechu* or *Bombax malabaricum* may be present as odd trees in (*a*) later retrogression stages on clays and (*b*) early successional stages on riverain soils. In the first case they will fail to form a community and develop into an *Holoptelea–Trewia* community whereas in the later case they may do so. It is, therefore, essential that a clear distinction be made between the two different dynamic systems

operating in adjoining localities for a clear understanding of trends in vegetational changes.

According to the above concept it may follow that in the area there are two chief developmental seres :—(*a*) Riverain sere (secondary or tertiary) on riverain soil which proceeds from *Acacia catechu* or/and *Dalbergia sissoo*→*Holoptelea–Bombax–Trewia* community and (*b*) Forest sere (primary) on Siwalik clays and conglomerate proceeding from a mixed forest of *Ougeinia*, *Eugenia*, *Terminalia*, *sal*, etc., to something with little or no *sal*. The earlier community on forest sere comprises of *Anogeissus*, *Ougeinia*, *Sterculia*, etc., the seedlings of which have been repeatedly found in areas where *sal–Eugenia* community has been felled. With the present data it is difficult to say what this forest without *sal* would be, but the evidence derived (1) from seedling growth in forests studied, (2) the floristic composition of Siwalik forests west of Dehra Dun—which at one time, not long ago were believed to have been good *sal* forests—and (3) soil data tend to show that next developmental stage for mixed *sal* forests of the Dun valley, may comprise of a community with only those associates of *sal* which have higher demands on soil minerals (see Puri and Gupta, 1950*c*, 1950*d*).

It is difficult to do more justice to the question of *sal* till study has been made of quality one *sal* forests of the Uttar Pradesh (United Provinces), however, it can be safely stated that *sal* community in the Dun valley under the present type of biotic influences is late developmental stage and not a climatic climax in Clement's terminology. *Sal* might have been a dominant tree in the past on all types of parent geological formations and soils but in the areas studied it is now definitely receeding to clays, perhaps under adverse human influences. Similar conclusions were drawn by Mooney (1947) from a study of *sal* forest in Orissa and Bastar State—southern or south-eastern limit of *sal* community. He states : "But along its Southern boundary in Orissa, Kalahandi and Bastar, I am convinced that the *sal* tree is in a dynamic condition ready to migrate southwards at any rate as far as the Godavari, were it not held up by axe-cultivation—in my opinion the chief limiting factor in the way of its southerly extension". Dehra Dun forests constitute the northern or north-western limit of *sal* forests. Similar difficulties in the regeneration of *sal* have been noticed in Bengal duars which is the eastern extremity of this community. It seems that the species is, perhaps, receeding from its area of distribution. Is this according to a natural law of population or it is brought about by adverse human influences—is difficult to say at present.

Summing up, from the above study in the Dun forests it seems clear that *sal* forests with *Shorea robusta*, at present dominant, or nearly so, are not climatic climax but represent a bio-edaphic seral association preserved in this stage by human influences. Chief climatic conditions tend to replace it by a community with little or no *sal* and the cumulative effect of human influences at most places, especially on conglomerate, bouldery soils, etc., seems to operate in conjunction with the climate and tends to accelerate this process of degradation. It is therefore, necessary that Silvicultural and other systems in vogue here be critically examined in the light of data here presented and modified to produce conditions that may not adversely affect the soil conditions and the sustained yield from these forests, which is, or should be, one of the chief aims of silviculture.

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A BRIEF NOTE ON THE FORESTS OF ANDAMANS

BY SHRI D. P. NAGDEV

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Name and situation.—The Andaman Islands are composed of a chain of about 200 islands lying in the Bay of Bengal. The more important islands are separated by narrow channels and form, to all intents and purposes, a single island usually referred to as the Great Andaman. These are about a dozen important outlying islands and apart from these and the Great Andaman, most of the other islands are little better than Coral reefs and of no interest from the forest point of view.

As a southern continuation of longitudinal mountain ranges of Western Burma, and separated from them by the Preparis channel, the Andamans occur as the peaks of the northern part of a prominent oceanic mountain extending in the Bay of Bengal, as far South as 6° 45′ North latitude.

2. *Geology.*—The North Andamans is hilly, the highest point, Saddle hill, being 2,402 feet above sea-level. The underlying rocks consist of sandstones and conglomorates, the latter predominating, except in the higher portions where the rocks are intrusive and consist of serpentine. The former produce a coarse rubbly sandy loam as a soil, while the latter produces a dark red loam. The former soil is very permeable.

The Middle Andamans.—The main formation is that of Eocene sedimentaries with the serpentine series of intrusive rocks occupying many of the hills and ridges of the Central and Eastern part of the island. The Eocene sedimentaries consist of sandstones and clays of the south, all three types being represented. The serpentine series consist of red and green jaspers, purple porcellanic limestone, hard grey and yellow quartzites together with occasional out crops of calcareous gneiss.

The South Andamans.—This consists mostly of sandstones and clays with out crops of igneous rocks of the serpentime series.

3. *Area of the forests.*—It is estimated that there are about 1,500 square miles of workable forests.

4. *Composition of forests.*—(*a*) The nature of the forest changes as one proceeds from the sea shore to the higher hills. Nearest the sea are the tidal forests containing magnificent stands of mangrove poles and other swamp forest species. These forests have so far been used for supplying fuel but they may yet attain greater importance. It is only in these forests that the stocking is satisfactory. Of the component species the most gregarious and predominating are :—*Rhizophora mucronata* and *R conjugata*. The largest mangrove, grows gregariously with a clean bole of 60′ to 80′ in height and a girth of 5 to 6 feet.

(*b*) Above the reach of high tide are the Beach forests. These are found along the coast in narrow belts. They grow on the detritus brought down by streams and on sand and shingles banked up by wind and waves. They act as very efficient shore protectors especially on the west coast. The most predominating species and most valuable sometimes growing pure is *Mimusops littoralis* (the sea mohwa or bullet wood tree) and the Poon—spar tree (*calophyllum inophyllum*).

(*c*) Next come the southern evergreen forests or low-level-ever-green forests which give the biggest timber in the Andamans. This is confined to the drained alluvium which forms the banks of the longer streams, moist valleys and depressions and the extensions of tidal flats. These are the densest forests in the Andamans and are of extreme value, *Dipterocarpus alatus* (Gurjun) the largest and most magnificant of the Andaman trees is found in this area. Other important species found here are *Diospyros pilulosa*, *Sterculia alata*, *Sterculia campanulata* (Papita), *Terminalia bialata* and occasionally *Pterocarpus dalbergioides* (Padauk). The above mentioned trees occupy the topmost storey of 100 ft. and over. Below these forming the second storey from 50′–100′ are *Lagerstroemia hypoleuca*, *Dillenia pentagyna*, *Dracontomelum mangiferum*, *Pometia pinnata*, *Myristica irya*, etc. Forming the lowest storey are found *Fagraea morindæfolia*, *Garcinia andamanica*.

(*d*) *High level evergreen forest.*—Here we find the grandest of the Andaman types containing trees of enormous height growth and

large girth. On very steep slopes and on the highest ridges and hill-tops the growth becomes stunted and the vegetation appears like an overstocked shrubbery. The principal large trees on the lowest slopes are *Dipterocarpus grandiflorus* (Gurjun), *Artocarpus chaplasha*, *Bassia butyracea* (hill mohwa) *Hopea odorata*, *Sideroxylon longipetiolatum*.

(*e*) *Deciduous and semi-deciduous forests*.—These forests according to soil conditions extend from the mangrove, beach or low-evergreen forests upwards to 300′ or more. They grow on soil derived from sedimentary rock and which does not retain water. They occupy the largest area of the Andaman types and contain as the chief species *Pterocarpus dalbergioides* (Andaman Padauk) associated with the following important species :—*Terminalia bialata*, *Canarium euphyllum*, *Sterculia alata*, *Bombax insigne*, *Lagerstrœmia hypoleuca*. These form the upper-most storey 100′ and over in height. Below these are found *Sterculia villosa*, *Dillenia pentagyna*, *Diospyros marmorata*, *Sageraea listeri*.

5. *Condition of the crop*.—It is difficult to describe the Andaman forests as they are to-day. The virgin forests really consist of scattered sound trees of commercial importance surrounded by useless species, some pole growth of valuable species and unsound trees, the whole intertwined by tremendous climbers. In all these types of forests, excluding mangrove, the tree growth is in the form of mixture of single trees. It is seldom except in the case of Gurjan, that pure groups are found and the marketable trees are found inter-mixed with the unmarketable. At many places in these virgin forests one can frequently meet Gurjun trees as high as 130 ft. with a clean bole of 90′, and girth at breast height being over 16 ft. Similarly Padauks of 70′ clean bole with girth of over 12 ft. are frequent.

6. *Method of exploitation*.—All work is done departmentally. After logging the logs are dragged by elephants over the corduroyed path to the rafting depot where they are taken over by a rafting crew and made up into rafts of about 80 logs each for towing or floating down the creeks for delivery later to the log carrying vessels. For a camp of 8 elephants which produces about 500 tons of logs (1 ton–50 cft.) a month, the log carrying vessels call about once a week and carry logs to the mill at Port Blair.

When the Andaman forests were first worked Padauk alone was considered to be of value. The war of 1914–18 brought Gurjun and other species into the market and as a result, fellings became more concentrated. But fellings were confined except in the case of Padauk to areas within half a mile of the banks of a creek suitable for rafting. Fortunately the elephant drawn tramway was constructed at this time, and this made timber, previously regarded as inaccessible, exploitable with some prospects of profit. But even so the cost of extraction is high because each favourable creek is bordered by dead country in which for half a mile all exploitable timber has been removed and in the case of Padauk for a far greater distance.

8. *Forest management of the Andaman forests*.—The forest management of Andamans in the past was little more than lumbering. There had been no real management. For more than 70 years the forests had been worked without anything material having been returned to the estate. The principle of sustained yield had been set aside. This was partly due to the fact that in the past the work of regeneration by natural means was in its infancy and secondly the work had just started in extracting timber by short length elephant drawn tramways. Since then both these innovations have proved a major success and this has revolutionized the whole position in the Andamans. In order to achieve the proper management of the forests, the revision of the working plan has been undertaken in the year 1948 and it is hoped that no stone will be left unturned to manage the forests scientifically.

9. *The silvicultural system*.—The silvicultural system is the selection system and the girth limit for Padauk and Gurjan is 9 ft. and over, and, for the match wood species is 6′–6″ and over. The regeneration fellings are in reality clear fellings and can be briefly described as under :—

(*a*) Felling of exploitable timber and extraction of logs begins in April and is completed by the end of February of the following year.

(*b*) Rubbish clearance which includes the removal of all weed and bush growth and the girdling of all the remaining growth is begun in December of the year of the

exploitation fellings and completed by the end of the following April. Debris burning is not done unless the accumulation of rubbish is excessive. Trees are girdled and not felled because the mass of felled trees render it difficult for weeding labour to move about.

(*c*) Two weedings are carried out in the year of the regeneration and in the following year.

(*d*) The first thinning is made in the fifth year and it is expected that the second and third will be made respectively in the tenth and twentieth years.

The rotation at present is 150 years for Padauk and Gurjun and for the matchwood species is 75 years.

The timbers of Andamans like Padauk Gurjun, Silver grey, etc., are not only in demand in the local markets of India but they are successfully standing in competition in the markets of the world. With the advent of the exploitation of the forests of North Andamans, the world will come into closer contact with the timbers of this isolated part of Indian Republic.

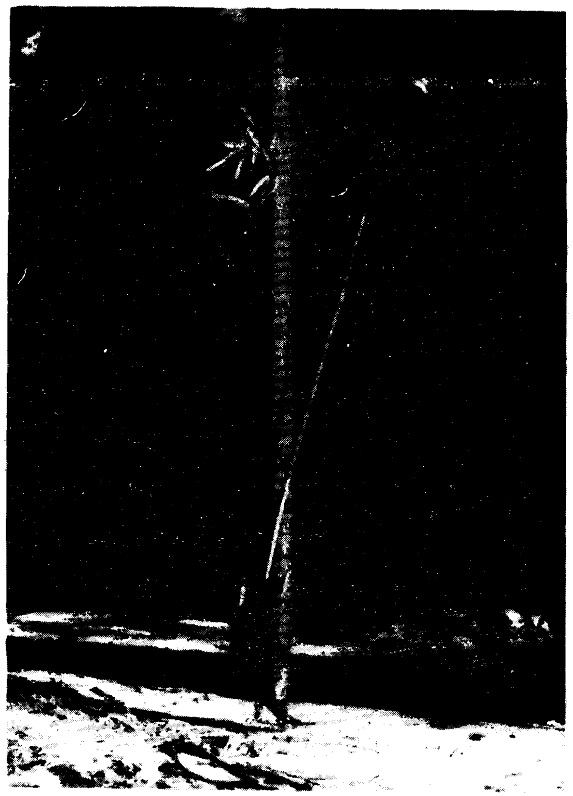


PHOTO NO. 1.—Root development on a *bambusa tulda* culm planted as a stake.

PHOTO NO. 2.—Vigorous growth of *Dendrocalamus longispathus* raised by horizontal cutting planting.

A PRELIMINARY NOTE ON PROPAGATION OF BAMBOOS FROM CULM SEGMENTS

BY S. N. DABRAL
(*Research Ranger, Forest Research Institute, New Forest, Dehra Dun*)

There are several known methods of the artificial regeneration of bamboos. The best method, established by comparative experiments and statistical analysis by the Provincial Silviculturist of Madras is by rhizome planting. Other methods such as direct sowing, entire transplanting and offset planting, have been done with moderate success. As bamboos seed at long intervals, some other method of propagating them, when seed and young seedlings or rhizomes are not available, is also of value. Success has been achieved by rhizome planting from fairly old Cephalostachyum plants in Madras, but even such rhizomes are difficult to get.

The writer observed growth in a bamboo staked as a support to a vegetable climber during the rains of 1948. A leaning culm over a compartment line from a clump of *Bambusa tulda* was cut at about 9 inches from the ground level and driven as a stake one and a half feet deep into the ground in June. By the end of the rains in October, a few new green leaves had developed from the node just above ground. On digging up the stake development of roots from the buried nodes were observed. (See Photo No. 1). The phenomenon was therefore further investigated, with *Bambusa arundinacea*, *Bambusa polymorpha*, *Bambusa tulda*, *Dendrocalamus longispathus*, *Dendrocalamus strictus* and *Thyrsostachys oliveri*. These are sympodial bamboos, caespitose with culms together in a tuft or dense clump and rhizomes are short, thicker than the culms, nodes prominent, internodes very short, tip turning upwards after growing horizontally for a short distance, so as to form an erect culm. The usual time of innovation of shoots is from July to September.

Culms were cut from the clump of each species with a sharp bill-hook, older culms of more than 3 years were avoided, nor were the young culms of the season used. The very slender tips of the culms were discarded and the remaining portion divided into 3 feet segments with oblique strokes with a sharp heavy bill-hook without splitting the culm wall. The cut was made just above the node which possessed a bud and complement of branches already developed with leaves. The branches were trimmed to 3″ to 4″ length, but care was taken not to injure the branch buds at the node. The segments contained most cases about three nodes each. In some cases single nodes were also cut with 3 inches on either side, and tried.

The segments were planted horizontally in trenches of sufficient depth to allow them to be covered at least one inch deep and soil was well ramed. The single node cuttings were planted slightly slanting in sand, as well as in ordinary soil, the nodes remaining under ground. The planting was done in the third week of June and shade was provided against direct sun, to protect against rapid evaporation of the soil.

By July sprouting was noticed in most of the bamboos from the nodes, and development continued till the end of October. The most promising results were obtained with *Dendrocalamus longispathus*, *Thyrsostachys oliveri*, *Bambusa tulda* and *Bambusa polymorpha*. (See Photo No. 2) *Bambusa arundinacea* and *Dendrocalamus strictus* our most important Indian bamboos gave poor response, the former not having sprouted at all, and the latter having given very stunted growth. The height development in inches is tabulated below.

Species	Height in inches on			Remarks
	22–8–49	16–9–49	29–10–49	
Dendrocalamus longispathus	61 (2)	68	132	The numbers in brackets indicate the number of nodes from which sprouts appeared.
Thyrsostachys oliveri	40 (2)	46	75	
Bambusa tulda	18 (3)	28	57	
Bambusa polymorpha	15 (2)	25	10*	* Top broken.
Dendrocalamus strictus	..	13	4 (2)†	† Sprouting had taken place but there was frequent rabbit damage.
Bambusa arundinacea	Nil	Nil	Nil	

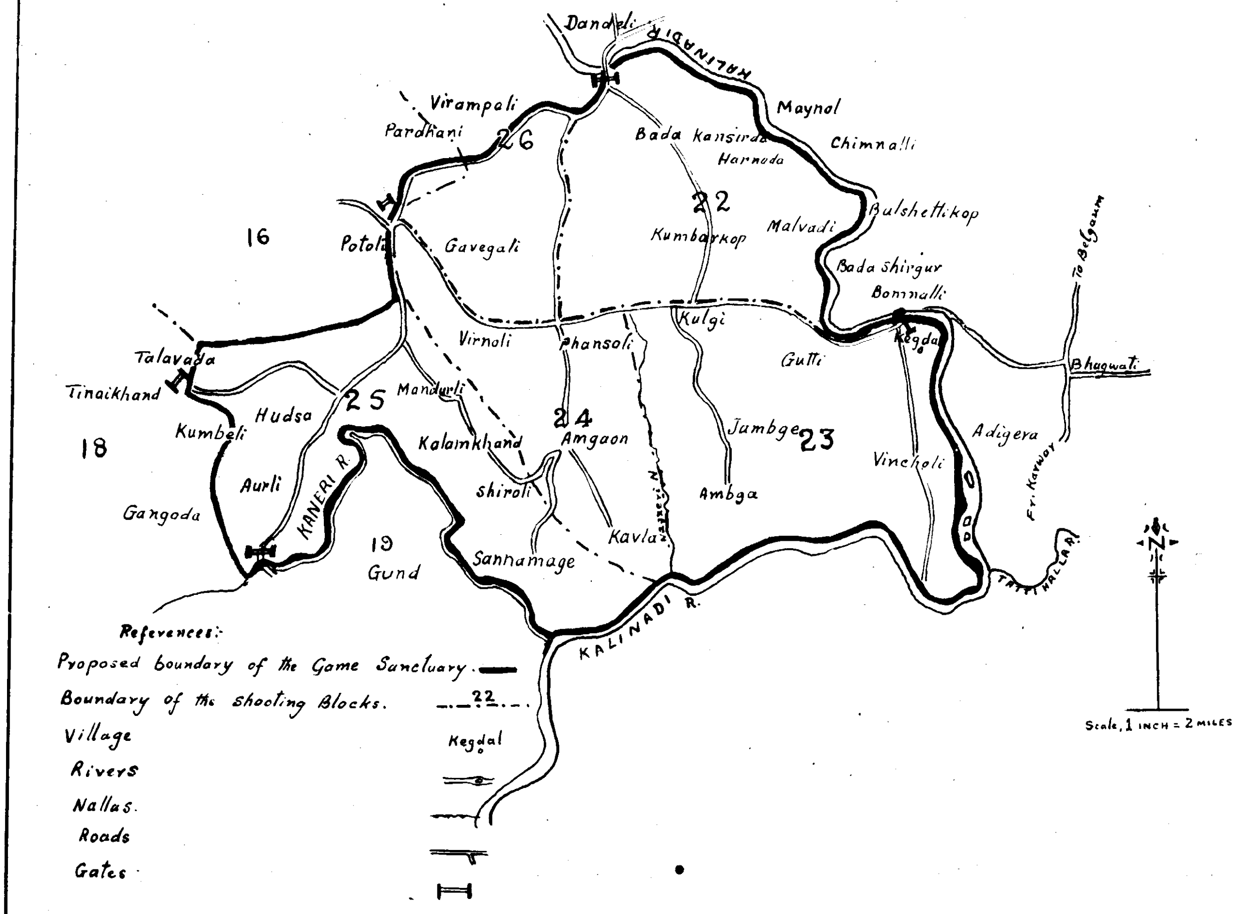
In the case of single node planting, though sprouting was observed, rapid decay followed probably due to accumulation of water in the hollow nodes, and probably resultant fungal attack and the method is therefore either not suited or requires greater precautions.

Experiments were therefore continued with Dendrocalamus strictus to find if the season of planting has got any effect, by trying three dates of planting and the results are given below. Sections from one year old and fresh (year's) culms were compared.

Date of planting	Number of culm segments planted horizontally	Number sprouted till 30-5-50	Average number of nodes from which sprouting was noted	Percentage of segments that sprouted
5-12-49 ..	10 Old	Nil	Nil	Nil
	10 New	Nil	Nil	Nil
5-2-50 ..	10 Old	2	1	20
	10 New	Nil	Nil	Nil
5-4-50 ..	10 Old	9	2	90
	10 New	Nil	Nil	Nil

The indications are that for Dendrocalamus strictus, three-foot long cuttings taken from two-year old culms planted horizontally, one inch below the soil surface, offer prospects of successful regeneration of the species, under the soil and climatic conditions of Dehra Dun.

THE GAME SANCTUARY IN KULGI AND VIRNOLI RANGES OF KANARA NORTHERN DIVISION IN SOUTHERN CIRCLE.



EXTRACTS

I

The following extracts are taken from a Translation from "O Journal" for January 8, 1950 on Brazil's agricultural areas

"Despite the vast territory available, our (Brazil's) cultivated areas look too small compared with those of other countries. Though Brazil is said to be an essentially agricultural country, less than 17 million hectares of lands have been cultivated. We are almost 50 million Brazilians and the excuse that there is no labour cannot be accepted. We have some 10 million rural workers, a number quite sufficient to do a country's agricultural works. With only 8·5 million workers, the United States cultivate an area infinitely larger, estimated at 150 million hectares.

"Our situation may be compared with that of Argentina. The latter's population is about one third that of Brazil. But only the province of Buenos Aires cultivates three products—wheat flax, and oats, in an area of 10,370,802 hectares, these products representing 13,000,000 hectares of the total country's production.

"Density of population and land cultivation do not have much relation with each other. China, with 450 million souls cultivate only 12% of its lands while France, with a population more or less the same as ours, cultivates 60% of its lands. Italy, also cultivates 60% of its total lands. Germany 45%; India 33%; Japan 35%; Poland 50% and England 20%.

"Brazils agriculture has been very neglected and in 1940, the Census showed 12,361,127 hectares of exhausted lands, a surface almost equal to that cultivated to-day.

"In no civilized country in the world is agricultural area so limited as it is in Brazil. Only about 2·21% of Brazil's lands are cultivated. Farming and pasturage put together account for only about 12·56%".

[It will perhaps facilitate understanding of the above extract if readers are reminded that a Hectare equals ten thousand square meters, or 2·4711 acres.—Ed.].

II

BAMBOO AND ITS APPLICATIONS

(The following extracts are taken from a translation from " O Estado de S. Paulo " dated January 8, 1950)

Some types of bamboo are being distributed to farmers in several Central American countries. All farmers are aware of the importance of bamboo in making baskets and other things. Bamboo has several varieties......The Forest Research Insitute of Dehra Dun, India, makes all its publications in paper made with bamboo, considered by specialists to be as good as the

best paper manufactured with wood-pulp. Therefore bamboo has a bright future in the cellulose industry. In the United States the average of one acre of pine tree gives 7·13 tons of pulp in plantations of 20 to 35 years of age, whereas bamboo trees 4 years old, in Trinidad, give four and half tons of pulp.

* * *

Bamboo is also used to make fine furniture and office articles. These bamboo trees can grow in lands which are not very fertile, and they do not require much rain to grow. In Porto Rico, farmers use bamboo trees as shade trees for beans, peas, and other plants, until they develop to their full growth. A bamboo plantation does not require much work and care.

* * *

Bamboo trees have been recently planted to protect other trees against erosion and winds. In orchards and gardens this procedure has given good results, so as to be considered by some an ideal protection for plantations.

* * *

With so many qualities and uses, bamboo may become one of our most important trees in our state, as it is in several countries of Central America.

[In Asiatic countries, especially in India, the utilization and growing of bamboo are well known. The above extracts are reproduced to show that there may be other uses to be investigated for example the planting of bamboos as a protection against wind erosion.—ED.].

III

DIGESTIBILITY AND NUTRITIVE VALUE OF USAR GRASS HAY (SPOROBOLUS ARABICUS)

(Extract from the Indian Journal of Veterinary Science and Animal Husbandry Vol. XIX, Part II, June 1949)

BY N. D. KEHAR, S. C. RAY AND S. S. NEGI

(*Animal Nutrition Section, Indian Veterinary Research Institute, Izatnagar*)

The digestibility and the nutritive value of usar grass hay have been investigated under a scheme of the I.C.A.R. to assess the feeding value of indigenous grasses. Usar grass as the name indicates grows on 'usar' or barren land in which the permeability of water is hindered by the formation of alkali salt hard pan a few inches below the surface. The soil moreover contains excess of sodium carbonate and sodium phosphate......It is seen that usar grass hay compares fairly well with that of Rhodes grass and some important minerals like lime and phosphate, in usar are quite normal for a hay. Due perhaps to the soil in which it grows, a peculiarity of the hay is that it contains a large amount of sodium and sulphur. From a number of analyses it has been found that usually the sulphur and soda contents lie between 0·6–0·8 and 1·5–2·2 per cent respectively......The hay was consumed by the experimental bullocks at the rate of 886 gm. per 100 lb. body weight which shows that it was fairly palatable......A tabulation of percentage composition on dry basis of usar and of some cultivated and indigenous grass hays showed that for a mature grass hay the digestibility coefficients of crude protein and other extracts are fairly high and compare favourably with those of Rhodes grass hay which is of similar composition. On account of the low digestibility of the carbohydrates of usar grass hay its energy value as represented by total digestible nutrients and starch equivalent is rather low.....It is seen that in spite of adequate supplies of calcium and phosphorus, the calcium balance is definitely negative and phosphorus also to smaller extent. Although the average nitrogen balance is positive, two out of six animals showed a negative balance. From the figures of urinary excretion it appears that a large portion of the absorbed nitrogen is simply deaminated and excreted through the kidney. The negative mineral balance and high nitrogenous excretions in urine suggest that under usar grass feeding, the physiological mechanism of the utilization of

nutrients is seriously upset. This may be possible due to the unusually high soda and sulphur content. The author's summary is as follows.

The digestibility trial conducted with mature usar grass hay showed that the hay is palatable. The digestibility coefficients of its crude protein, ether extract and total carbohydrates are 42, 41 and 43 respectively and the nutritive value calculated was found to be 2·57 lb. digestible crude protein, 39·65 lb. total digestible nutrients and 19·4 lb. starch equivalent per 100 lb. of dry hay.

Due to some undetermined factors the normal metabolism under usar grass hay feeding is digested, as is evidenced by the negative calcium and phosphorus balance of the large excretion of urinary nitrogen.

IV

INVESTIGATIONS ON FAMINE RATIONS: PANEVAR (CASSIA TORA LINN.) SEED, A PROTEIN HIGH FEED FOR LIVE STOCK

(Extract from Journal of Scientific and Industrial Research 1950, V. 9 B., No. 3, pp. 77–78)

BY N. D. KEHAR AND V. N. MURTHY

In green condition, neither the leaves nor the pods are ordinarily taken by animals...... But when the seeds are thoroughly dried in the sun for 15 to 20 days and then gradually introduced into the ration, the animals develop a taste and in about 15 days 50 per cent of the concentrate can be replaced by these seeds...... It will be observed that it compares favourably with gram in protein contents and is definitely richer than the other cereals. The calcium and phosphorus contents of the seeds are definitely higher as compared to the other seeds. Unlike the other concentrates and cereals, the calcium phosphorus ratio is very well balanced in these seeds an important factor in the metabolism of calcium and phosphorus.

V

SUMMARY AND CONCLUSIONS

(Extract from "Rainfall Interception by Chaparral in California" 1949, page 30)

Studies were conducted at research centres in central and southern California to determine the loss of rainfall as a result of its interception by shrub vegetation. At North Fork in the foothill wood-land-chaparral sub-type of central California two studies were conducted: One in partially deciduous ceanothus-buckeye-oak vegetation and another in evergreen ceanothus-manzanita vegetation. At San Dimas Experimental Forest in the southern California chaparral formation a third study was conducted in the evergreen scrub oak-caenothus type. Gross rainfall, throughfall (the quantity of rain actually falling to the ground), and stemflow (the rain which reached the ground as flow down the shrub stems) were measured. Interception loss was computed from these measurements.

Five per cent of the gross rainfall was lost annually in the buckeye-ceanothus-oak vegetation at North Fork. This vegetation was partly deciduous; the interception loss under fall-winter conditions when the deciduous shrubs were bare was slightly more than 4 per cent, but under spring-summer conditions when the deciduous shrubs were in leaf, the loss was about 14 per cent. The higher spring-summer loss, although due largely to the increased density of the vegetative cover when in full foliage, was also due in part to the smaller average size of the spring-summer storms. Eight per cent was lost annually in the ceanothus-manzanita vegetation at North Fork, and 11 per cent was lost in the oak-ceanothus vegetation at San Dimas. In general the annual loss of rainfall through interception ranged

from 1·7 to 3·9 inches, depending on the total annual rainfall and the character of storms producing it.

Stemflow was influenced to a considerable extent by the branching habit and character of the bark of the various shrub species. Shrubs of the wood-land-chaparral at North Fork (a large part having smooth bark and upright stems) yielded an average of over 11 inches of stemflow out of an average annual precipitation of 38 inches. On the other hand oak-ceanothus species at San Dimas (having comparatively rough bark and spreading branch habit) yielded an average of only slightly over 2 inches of stemflow out of an average annual rainfall of 27 inches.

Throughfall, stemflow, and interception loss were generally directly proportional to storm size. For small storms the amount of interception loss can be as much as 50 to 75 per cent, and for large storms as little as 3 to 6 per cent of the gross rainfall. The relation between precipitation and interception loss is curvilinear for small storms of less than 0·30 inch in size, and linear for storms of more than 0·30 inch. Equations are given for estimating interception loss in storms of more than 0·30 inch.

Analysis of the interception process, using rate data, showed graphically how interception loss accumulated during typical storms. For a long storm interrupted by several rainless intervals, alternate wetting and drying of the vegetation caused relatively great interception loss. For two short storms having almost continuous rainfall, evaporation caused only small additions to the loss after initial wetting of the vegetations ; consequently, total interception loss was relatively low.

Results of the three studies show that stemflow is an important factor of the interception process and cannot be ignored in considering the disposition of rainfall in brush types. The quantities of stemflow from chaparral species are not negligible amounts such as have been reported by investigators who worked with coniferous tree species. The average annual stemflow for the three studies was 7½ inches or about 20 per cent of the total rainfall.

Had these three studies measured interception loss simply by catching the precipitation falling through the vegetation, the loss would appear to be 19 to 38 per cent of the annual precipitation. Only 5 to 11 per cent was lost.

Stemflow is all the more important as an addition to the ground-water regimen because it is delivered as a slow, steady flow at the base of the shrubs. Here the soil is loose and friable ; well covered with litter, it has a high infiltration capacity. The stemflow is readily absorbed, making a significant contribution to soil moisture.

VI

CASHEW NUTS

Cashew nuts, known sometimes in Madras, as Promotion nuts are well known in India. The Botanical name of Cashew is *Anacardium occidentale* which means the heart shaped nut of the West. Ana in greek means resemblance, and cardium means heart. The tree appears to have been originally introduced from South America, and is now established in our coastal, and inland sandy areas. The Hindi name of Kaju is probably derived from the Brazilian name Acaju, and transliteration into French and English have changed it into Cashew. While this is the correct origin, there is a quaint story in Malabar that when the early portugese visitors asked a cashew seller in Malabar what it was, and he said "Kasinnettu" which in Malayalam means eight for a pice and they took Kasu (= a pice) for the name. We do not vouch for the accuracy of this version. It is a low spreading tree which is easily raised by direct sowing. In addition to the edible kernel of the nut, and the fruit, really the enlarged stalk of the fruit proper which is the nut, the tree produces other valuable products. The wood is used for packing cases, boars, and charcoal in Burma. The reddish or yellowish bark gum, slightly soluble in water is reported to be obnoxious to insects. The juice from incisions in the bark is used as a marking ink. (Compare name Marking nut for *Semicarpus*).

The astringent juice is said to be useful as a flux for soldering metals. The bark may be used for tanning. The pericarp gives an astringent oil, called Cardol, used for preserving fishing nets, and for painting on boats, and now-a-days used as a vehicle for paints, and in indigenous medicine. The fruit juice can be converted into Power alcohol. The fruit is said to be a remedy for scurvy.

Even at the risk of repeating some of our observations above, we give below an extract from a translation of an article on "Cashew Apple" by Prof. F. A. de Moura Campos of the Medicine School of the Sao Paulo University taken from "A Gazeta" (Sao Paula) for February 4, 1950.

"The Cashew tree is indigenous to Brazil, though being a tree of the littoral region in sub-tropical zones, it has been growing in Peru, Mexico, South Florida and India.

"Anchietta tried the fruit and said "they are like fine pears with a nut on top, which is better than those of portugal". Jean de Lery, Gandavo and Gabriel Soares have described it in greater detail. Martius describes the preparation of "Caulim" a beverage used by Brazilian Indians from the Cashew. The word Cauim is probably derived from the Brazilian Indian word "acayu-y" meaning cashew apple.

"Cosme Perira, Gomes de Castro e Magelhaes, Brazilian doctors of renown in the last century spoke of the therapeutic value of cashew apples. The latter said that rickety and feeble individuals suffering from rheumatism went to a sanatorium on the borders of the State of Sergipe, where there were many cashew trees. There they started to drink Cashew apple juice in good quantity daily. The result was that they all returned healthy and strong. Other scientists such as Araujo Feio, Furtado, Martina, Bonchristiano, Costa e Carvelho Paula Sousa, Wancolle, Wanderley, Peckolt, Parahym Leslie, Paula Rodrigues, Paula Descartes, Salvatore, Costa, Motta Pinho, also observe the great nutritional value of the Cashew apple.

"The Cashew tree belongs to the Anacardiaceæ—the same family to which the mango tree also belongs.

"There are three varieties of Cashew :—

"1. *Anacardium giganteum* Hancock, known by Brazilians as 'caju-assu' which abounds in the Mato Grosos State, where the natives call it caju-y ;

"2. *Anacardium corymbosum*, known by Brazilians as 'caju do campo' ;

"3. the common cashew apple that grows on the shores, the tree of which is called acajaiba or acajuiba by the Brazilian Indians.

"The French call it acajou, the Germans Kas chu, the Spaniards maranon, the Italians anacardo and the English and Americans Cashew Apple. In the north of Brazil unripe small cashew is called 'Meturi'.

"Cashew apple has a juicy part which people wrongly call fruit. It is just its flower stalk that grows that way. The fruit actually is its nut. The fruit and nut are widely used in refreshments and ice creams, and we may consider besides 'cajuada' the following products: 'cajuina' (concentrate cashew apple juice with fish glue) ; 'tumbanca' (fresh juice mixed with the nut flour) ; 'maturim' (Toasted nut) ; 'mocoroco' (fermented spirited juice) ; 'carapinhada' (juice, milk and ice cream, vinegar, jellies and sweets.

"Researches by the Department of Physiology have proved that toasted cashew nut is rich in calcium salts (0·765 *g* per 100 *g*), with high calorific value (6397 calories), with a sufficient quantity of iron salts (4 mg.) and B 1 vitamin, and traces of A and D vitamins. It is rich in nitrogenous material ; and is easily digestible. The cashew nut is therefore almost as good as animal products as eggs, milk and meat, though vegetable proteins are generally considered inferior.

"Experience has proved that cashew nuts used in a diet as the only source of protein may guarantee normal growth in young people, and correct dietetic deficiencies in undernourished animals.

"The juice of the flower stalk (the fruit as it is ordinarily called) contains B 1 vitamin and is extraordinarily rich in C vitamin. Paula Santos and Orsini found that the red Cashew apple is richer in this respect than the yellow cashew apple. No foreign fruit excels the cashew as a source of vitamins. It is superior to lemon in ascorbic acid, and it occupies a very important position among fruits, due to this reason.

"If there are any trees that should be planted in our orchards and public gardens, and in childrens' gardens, cashew apple trees should be included. Nice and leafy it gives a fruit of great value. If both the flower stalk (fruit) and the nut are used, a good food combination is obtained. Incomparably superior to apples and pears, which frequently are found on our tables, the Cashew apple is a real golden apple".

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AFFORESTATION OF WASTE LANDS AS PRACTISED IN WEST BENGAL IN COMBATING THE SOIL EROSION PROBLEM AND MEETING THE SCARCITY OF FUEL AND FODDER, Etc.

BY V. S. RAO, I.F.S.

(Deputy Conservator of Forests)

This article deals mainly with Midnapore where the writer had the privilege of working and gathering experience.

In the Midnapore district there are about 395 square miles of waste land. The country is very broadly undulating with an average slope of about 1 in 100, the gradient increasing towards rivers and waterways. The soil contains iron compounds and tends to form laterite on its lower layers by the leaching action of rain water. It has a large admixture of courSe particles, becomes soft and easily erodible in rainy weather but cakes hard when dry. The blocks of waste lands vary from a few acres in extent to thousands of acres. One stretch of waste land at Arabari has an area of over 3,000 acres. Another near Dudhkundi is over 10,000 acres in extent. These waste lands are a result of the destruction of the original forest cover, mostly of sal which is an edaphic climax due mainly to annual forest fires. Waste lands adjacent to forests, and having a clothing of sparse scrub and sometimes a few scattered Mahua trees (which is the only species respected in this locality, for the inspiring product of its flowers) are known as Dahi; and lands which have been successfully stripped of all vegetation are known as Danga. Hundreds of tons of the easily erodible soil from large stretches of *danga* and *dahi* are washed annually into the depressions, waterways and rivers, choking and flooding them during periods of heavy rainfall, with little or no moisture left in the subsoil to follow on in the shape of perennial springs. Floods and drought are thus the direct result of misguided (or rather unguided) human effort, though mistakenly considered to be acts of God by a population steeped in piety and ignorance. The courseness of the soil of the uplands (which in some places almost reminds one of sea-sand) is due to the removal of several inches of fertile top-soil by water erosion. The loss amounts to feet in some places where the underlying laterite has been exposed. The more spectacular form of erosion—namely gully erosion—is not commonly evident except in the proximity of rivers where the gradient is steeper. Correlated with erosion is the lowering of the underground water table, a reduction in atmospheric humidity, and, more distantly, a reduction in annual rainfall.

In the coastal areas—especially of Contai sub-division—there is trouble from high winds which blow with remarkable vigour and relentless steadiness for over 7 months in the year heaping up loose sands from the beach and continually blowing them inland. In some places the inland base of a sand dune was noticed to have progressed as much as 30 ft. in 3 months! There is also in this region a danger from tidal waves like the one that played havoc in 1942.

The fuel problem of the Western half of the district is purely artificial. There are over 400 square miles of sal forest and their produce is sufficient to meet the needs of the population. But the purchasers of the coupes of private forests are believers in big money and care to trade only with Calcutta inspite of the fact that wagons are not easily available. The local population depends to a large extent on head loads of non-sal firewood some of which look like bundles of magnified tooth-sticks. On the large waste lands as at Dudhkundi people grub out even the roots of the scrub jungle for firewood, thus aiding in the acceleration of erosion by depriving the soil of its last hold.

In the eastern flat lands of Tamluk, Ghatal and Contai sub-divisions there are no forests. and the fuel problem is very acute. Villagers are reduced to burning cowdung and paddy straw. Roadside trees are systematically destroyed where they are available. The fodder problem is acute all over the district, for the dangas do not even produce good forage. Even the culms of grass cannot draw sustenance from the eroded and arid land and the large wastes form exercising grounds (rather than feeding grounds) for lean and hungry cattle that are prepared to devour anything which has a remote semblance of greenery.

For a district where there are over 400 square miles of forest the problem of timber is strangely, even more acute. With regard to this commodity the district is dependent on Orissa, Bihar and C.P. As a natural concomitant of the non-availability of timber, skilled carpentry is also rare. When constructing a building, the timber portion is the biggest bug bear. For instance it is simpler and more satisfactory, whatever the cost, to place order for doors and windows at Calcutta than to get them made locally by inefficient carpenters with local timber containing large proportions of sapwood. Sal which is here cut at a rotation of 10 years or earlier cannot produce timber. Piasal which elsewhere is reputed to be a good cabinet timber has earned a bad reputation here because trees are cut long before maturity. *Holoptelea*, Arjun and Mahua are the only trees which yield large sized logs for planking.

The problems thus are :—(i) to prevent the large scale soil erosion which is going on in the district ; in the coastal regions to fix the shifting sands and to afford protection against the fury of wind and wave ; (ii) to provide fuel to the agriculturist by creating fuel reserves within easy reach and help him in releasing cowdung for his fields ; (iii) to promote the growth of fodder for cattle ; (iv) and to grow useful species of timber for local requirements and if possible for the use of industry.

The solution to the above problems is the afforestation of waste lands. The pride of place is to be given to the all important problem of soil erosion. To check this serious menace it is imperative to put the rolling waste lands under permanent vegetative cover at the earliest date possible.

Luckily for us we have a certain species of tree which is fast-growing, capable of flourishing on many different types of soil and which, being a leguminous plant, bears on its roots nodules which carry nitrifying bacteria. The lucky part of it is that the seeds of this species are available in abundance alongside the road of the W. & B. Directorate. Another leguminous species available in good quantity but a poor germinator is *Peltophorum ferrugineum*. A very useful pod-bearing plant, *Cassia siamea* is unfortunately not a roadside species. And its seeds are not readily available in such large quantities as we desire. These together with a few other legumes, viz., the Rain tree (available on roadsides), the Madras thorn (which can be collected in small quantities locally or bought from Nursery-men) and *Acacia moniliformis* (which can be gathered in very small quantities locally) form the matrix of our plantations. (None of the above species and none similar are available in the forests of this district).

The most important requirement for the successful establishment of a plantation in a reasonable period is protection against the ravages of hordes of hungry cattle. In our country only field crops are sacrosanct. Forests and even forest plantations are not. No vegetation can stand the daily onslaught of cattle. Two ways of cattle-proofing a plantation are (i) by surrounding it with barbed wire fence (ii) by surrounding it with a cattle-proof trench. Both are costly ; the cost being -/6/6 to -/8/- per running foot. The trench has the advantage that it holds the water running off the land and helps in keeping at least the margins moist. It aids as a water-conserving and erosion-checking medium on the rolling uplands of this district. The earth from the trench is heaped on the inward side of the plantation as a second line of defence against cattle.

If we were to depend on established tree growth to do the job of counter-acting erosion we have to wait several years for the plants to grow and spread and reach their branches half-way across the standard 6 ft. gaps between our rows of plants. But the arresting of the flow of water on the sloping land in order to prevent soil-wash and to conserve the moisture is a matter of immediate importance. The retention of moisture in the soil gives a great impetus to the growth of seedlings. Plants do

extremely well on moist porous soil and in shallow depressions, whereas a few inches away where soil conditions are different they are small and stunted in growth. Conservation of moisture is achieved by digging trenches *along the contour*. For gentle slopes trenches 2 ft. wide and 1 ft. deep at distances of 50 ft. are efficacious. Where the land is steeper the trenches have to be nearer and deeper, say 2 ft. wide and 2 or 3 ft. deep. The soil from the trenches is arranged as a bund on the lower side as an additional obstruction to water tending to run down the slope. The growth of plants along the bunds of the contour trenches and the cattle-proof trench is remarkable. A point of some importance is to keep blocks of earth uncut inside the contour and cattle-proof trenches at distances of 100 to 200 ft. apart. This is necessary to prevent movement of water within the trenches, as the cattle-proof trenches which bound the plantation are not necessarily along the contour, and even the inner contour trenches cannot be 100% perfect.

All the bunds can be sown up with any useful tree species or planted up with Sabai. Growth of plants on the bund, as has been remarked above is superior to that of plants elsewhere. At the base of the bund along-side the cattle-proof trench, bamboos are planted at distances 20 to 24 ft. apart.

The foliage of most of the leguminous fuel species mentioned above can be used as fodder. As regards timber species the following have been so far found to do well :—

Piasal—A good cabinet timber and a local species.

Babul—In moist situations only. Its fruit are fed to cattle to increase milk. Its timber is of great use to the farmer.

Sisoo and Rosewood—This is an especially good germinator and has done well both in dry and moist situations. Both sisoo and rosewood are timbers of great repute.

All the above are leguminous species and are hardwoods. Non-leguminous hardwoods found successful are :—

Sal—The only thing against it is that its growth is slow.

Jarul—A good all round timber. Requires moist situations.

Mahua—Grows to large size in this locality. Also yields important minor products in the shape of flowers and fruits. The local people consider it a Kalpataru.

Arjun—Grows well in moist situations; one of the commonest planted species in the Midnapore district. Its timber is used for dinghees and boats in this district.

Ghamar—The growth of this species in the first year is remarkable. This is an extremely useful timber for doors, windows and light furniture.

Kanju—*Holoptelea integrifolia*. A light-coloured timber. The species is one of the few found in large sizes in this district.

Neem—This is a very hard species yielding fairly good timber.

One species which occurs in this locality and grows to big size and is of some commercial importance is Haldu. This will be tried out. Others which will also be tried are Jam and Kathal.

Of the softwoods, Simul is put out at a spacing of 48′ × 48′ all over the plantation. Pitali has proved to be an excellent germinator. Its further growth is being watched. It is a good softwood, prized even for match-manufacture. Specimens of *Ailanthus excelsa* have been found to grow to a good size on the hard lateritic soil of Kharagpur town. Some seeds have been collected and have been put in the nursery. Their germination was good and they will be tried out under field conditions. Paper mulberry which has germinated in the nursery is also awaiting trial. A tree which grows to big size in this locality is Chatiwan and this too is going to be tried out.

Of the plants yielding minor produce the following gave good results :—

Soapnut, Bohera, Tamarind, Kusum and Cashewnut.

The last species has done remarkably well even on the very dry Arabari *danga*. Its savoury nuts are readily saleable and fetch good prices.

As forest trees are sown or planted in lines 6 ft. apart, the interspaces are available for the raising field and cover crops and crops of fodder until the forest plants grow big and

their branches meet across the lines. The choice of field crops is limited by the extremely impoverished condition of the soil and the impossibility of irrigating these uplands. Intensive cultivation and tending of agricultural crops are too expensive from the forest plantation point of view. The capital outlay involved in the initial breaking up and intensive cultivation of the soil is not justified considering the fact that crops can be raised for one or two years only. The following are the results of experiments so far conducted :—

Arhar—Germinated and grew well but seeded poorly. It is hoped that a better crop will be obtained next season, from the same plants.

Jute for multiplication of seed—Did well in the moister localities.

Short staple Cotton—Results are good.

Bhutta—Grew to a short height and bore sterile flowers. Has been a failure.

Ground Nut—Not very successful.

Boga—As a cover crop boga has done extremely well and has kept the area green throughout the year.

Experiments with long staple cotton are under way.

To revert to fodder, Napier grass from cuttings planted out last July, has done exceptionally well. Our intention is to increase the area under Napier grass as far as our own resources and those of the Agricultural Directorate permit. Once we have large enough stocks we can take up the question of planting village wastes with this species for the use of the agricultural population.

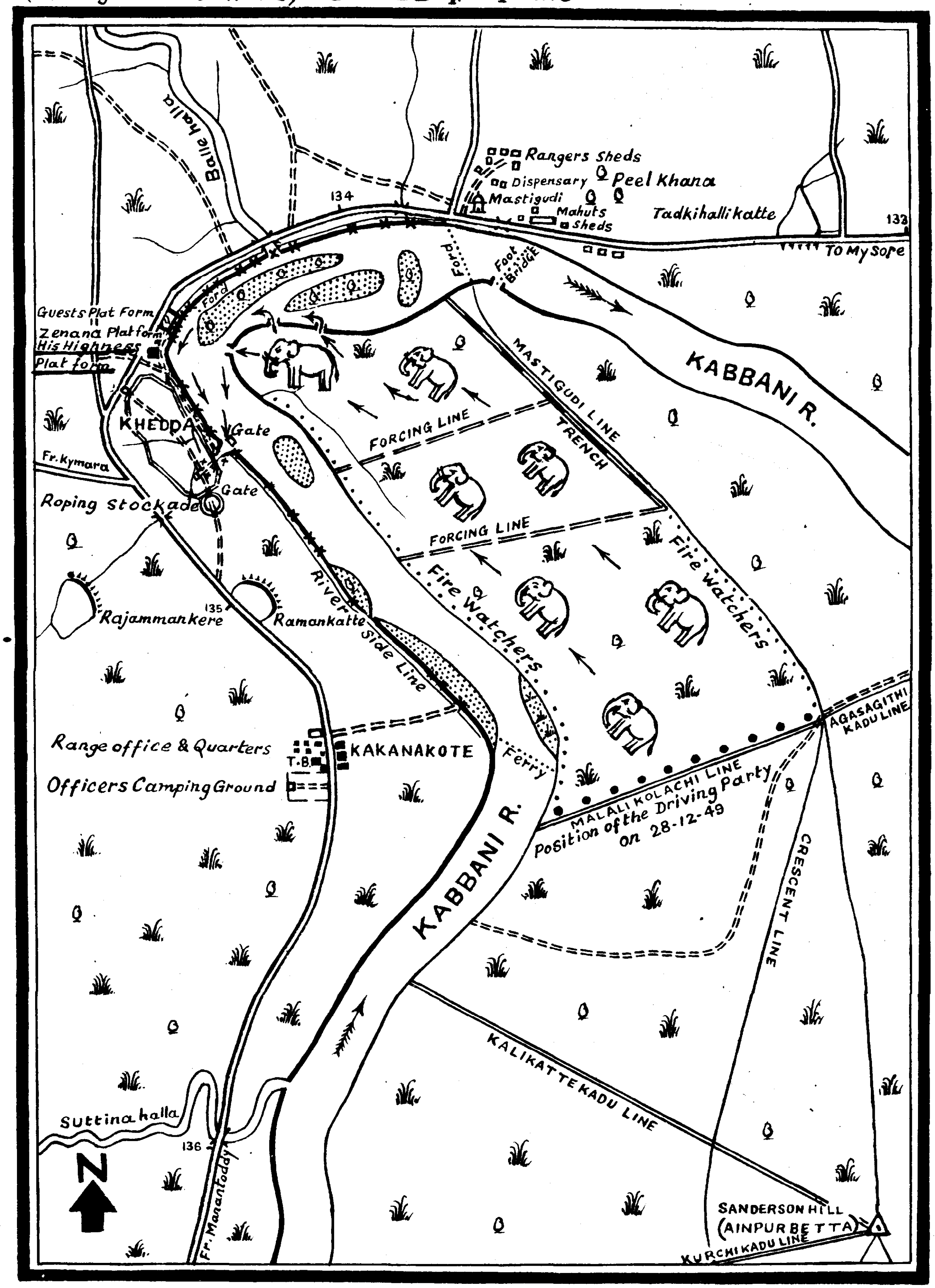
Manual operations on this hard lateritic soil for the purposes of forest plantations or field crops are very expensive. A hired tractor could plough up the entire surface at one-third of what it cost to have lines hoed up 6 ft. apart. This is of great importance from the point of view of raising field crops. It is of even greater value as a measure of soil conservation, because breaking up the hard soil into big clods helps it to soak and retain a larger proportion of the atmospheric precipitation. Even the forest seedlings in the tractor-ploughed area are naturally healthier and more rapid in growth.

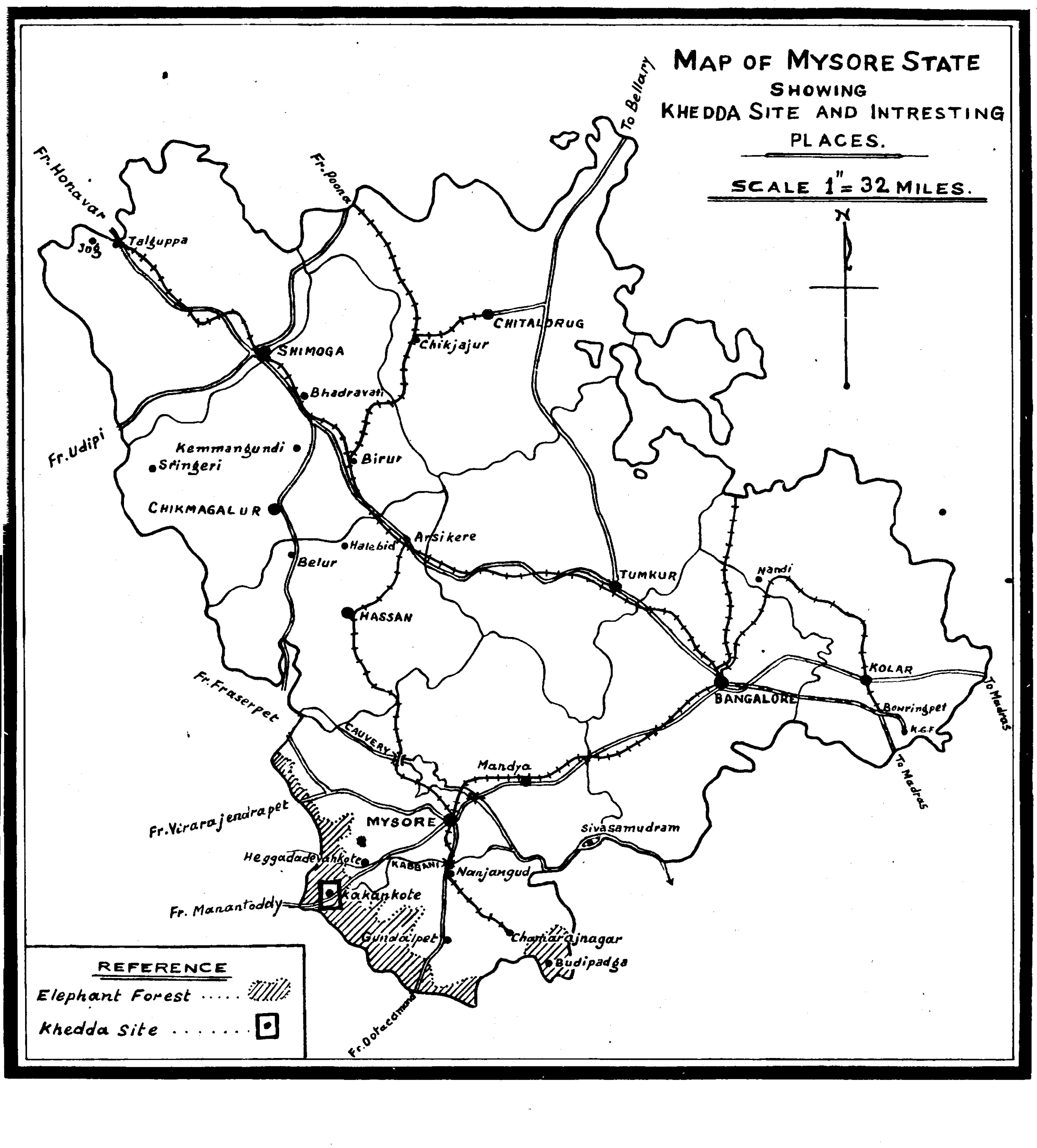
In the coastal areas the procedure is naturally different. Cattle-proofing on sand can be done only by means of wire fence. Contour trenches for arresting run-off have also no meaning in porous soil. Protection from cattle induces a good growth of grass in 2 or 3 seasons. The species that can be planted on sand are very few—Casuarina, *Acacia moniliformis* (an Australian wattle), Cashewnut, and *Calophyllum* in moist, protected localities. In the tidal areas, the plants that can grow are of the Sundarbans type. Gewa, baen and white baen, garan, math garan, garjan, dhundal passur have all done well. The last four species do not occur locally. The first four are found naturally in the tidal areas of this region but are kept in a stunted state by men and cattle. Protection from both these agencies can be offered here, only by engaging men to patrol the area. Large blocks of forest of the Sundarbans species in these tidal mud flats, and of Casuarina, etc., on the sands will be a formidable bulwark of protection against the fierce elemental forces of wind and wave in this locality, besides meeting the very acute scarcity of fuel in these forestless tracts. The tidal forests can also be formed into a sanctuary for wild fauna. There are 10,000 acres of tidal area and 40,000 acres of waste sand (both littoral and inland) that can thus be afforested.

A word about choice of species. We are often asked why we do not attempt to grow teak here. The answer is that teak does not flourish on lateritic soils. We have to grow species suitable to the soil. The soil of Nadia is admirably congenial to the growth of teak and it is there that we are forming teak plantations. The other question is why not plant up all the wastes with Sabai. While this might temporarily solve the problem of raw material for paper pulp the clump-forming sabai grass certainly does not check erosion, and our greatest problem will remain unsolved, viz., loss of top-soil, clogging of rivers, alternate flood and scarcity of water, lowering of the underground water table and drying up of subterraneous springs. We shall only be creating a more serious problem for the next generation.

KAKANKOTE KHEDDA MAP DECEMBER 1949.

(Showing the final Phases) SCALE 4" = 1 Mile





MAP OF MYSORE STATE
SHOWING
KHEDDA SITE AND INTRESTING
PLACES.
SCALE 1" = 32 MILES.
N
Fr. Honavar
Jog
Talguppa
Fr. Poona
To Bellary
CHITALDRUG
Chikjajur
SHIMOGA
Bhadravati
Fr. Udipi
Kemmangundi
Sringeri
Birur
CHIKMAGALUR
Halebid
Arsikere
Belur
TUMKUR
Nandi
HASSAN
KOLAR
To Madras
BANGALORE
Bowringpet
K.G.F.
To Madras
Fr. Fraserpet
CAUVERY
Mandya
Fr. Virarajendrapet
MYSORE
Sivasamudram
Heggadadevankote
KABBANI
Nanjangud
Kakankote
Fr. Manantoddy
Gundalpet
Chamarajnagar
Budipadga
Fr. Ootacamund
REFERENCE
Elephant Forest
Khedda Site

THE MYSORE KHEDDA—1949

BY M. A. MUTHANNA
(*Chief Conservator of Forests, Mysore*)

Preamble.—In Mysore State two kinds of Khedda operations are conducted. First is known as the Mysore Khedda and the second as the Chance Khedda. The latter is conducted purely on a commercial basis when the wild herd is driven to captivity as soon as the same is surrounded. This is less spectacular but financially more paying. The former with which this article deals is conducted with the accessary arrangement to entertain distinguished guests and is considered an unique show in the world of sport.

The "Khedda Operation" is essentially an Indian technique evolved to capture a herd of wild elephants in their native habitat. The word 'Khedda' itself means a "Trench" a reference to a V-shaped ditch surrounding a carefully selected plot of land into which the herd is driven by a series of manœuvres to its captivity. Many changes and refinements have since been added and developed as a result of the accumulated experience over several decades ; so much so, it would not be incorrect to refer to the operations, actually in practice in Mysore to-day as the "Mysore Khedda".

In 1887 the ryots living round about these elephant forests brought to the notice of the Mysore Durbar that owing to a large increase in the numbers of elephants, crops were in immediate danger of being ruined by these elephants. In 1888 to meet their pressing demand the Mysore Durbar invited Mr. Sanderson, Superintendent of Government Kheddas at Dacca to organize a Khedda operation in this State and in 1889 the first Khedda operation was held and witnessed by H.R.H. Prince Albert Victor. Since then the Khedda operations have been held periodically to coincide with the visit of distinguished visitors to the State like Prince of Wales, Viceroys and the Prime Minister of India.

The Mysore Khedda has now an almost international repute as one of the most thrilling and spectacular forest "shows" which Indian forests offer to the sight-seer. This is no doubt true but the spectacular element is only incidental to and not the main reason for staging a Khedda. The raison-de-etre of the operation is to capture a herd of elephants which is a valuable commercial "Forest Product". Even in this Machine-Age, the elephant is still an efficient and economic unit of power for logging in the forest ; the animal is also in demand for possession as a symbol of royal splendour in palaces and of holy dignity in temples and Mutts ; then there are the Zoos and Circuses which prize the elephant. Thus, there is a *commercial* demand for this noble animal and the Khedda is a business operation which if successful should show a balance on the right side of the Cash-Book. Incidentally the Khedda is conducted to protect the agriculturist from the depredations of the elephants which raid the ryots' fields fringing the forest. This again is a *strictly utilitarian operation.* Such prosaically commercial reasons for the Khedda would no doubt disappoint the romantically minded to whom the Mysore Khedda appeals most as a "Show".

To appreciate the magnitude and complexity of a Khedda Operation one might just picture the elephant in his home. The elephant is one of the largest living land animals, powerful and intelligent. He lives as a member of a social community—each herd having a leader who has all the privileges and responsibilities of a head of a clan and invariably this unique honour is bestowed on the oldest cow elephant. (Occasionally an elephant is, for various reasons, ostracized and driven out from the herd when he becomes a "Rogue", a savage brute of great power and mad fury. This does not, however, enter into the picture here as a "Rogue" is *never captured by the Khedda* technique). Captained by these strong and sagacious leaders, the herds roam about the forests, know every inch of the ground, rarely interfere with other denizens of the jungle, never brook the slightest interference to themselves and are verily the lords of all forest. To decoy such a herd and trap them in a pound at a given spot on a given day and yes, even at a fixed hour of a time-table, calls for sound planning, elaborate organization and meticulous attention to a large mass of details each

one of them apparently trivial in itself but vital to the success of the operations as a whole.

In fact, this planning organization and attention to details of Khedda operation can most aptly be likened to a military operation. The General with his staff lays down the broad outlines of strategy and guides the operations at every stage and lays down a time-table. Subordinate Officers are in charge of sections all working in their framework. Constructional works, the recruitment and maintenance of labour (which at its peak consists of about 1,500 men), their keep and feed at widely scattered spots in thick jungle, health, sanitary and auxiliary service communications, supplies, the feed of the captive elephants (which are very very fastidious in their tastes) as well as the tame ones which assist in the operations (called the "Kumkies") are illustrative of the magnitude and complexity of the task.

These Khedda operations are held in the famous forests of Kakankote which lie about 50 miles South of Mysore.

Right through the heart of these forests flows the most beautiful River Kabbani—on the fringes of both its banks grow the giant bamboos which dip their leaves into the river like some gigantic ferns. The Forest itself contians big and small bamboos and in all respects presents an ideal home for the elephants. In addition to the elephants, large herds of bison have made their home in these forests. These forests are also easily accessible and are served by a network of roads and the high road, Mysore–Manantody, passes within a few yards of the site where the elephants are impounded.

Long before the eventful day, and even before the herd is sighted, many preliminary arrangements are necessarily to be made.

The Khedda area of 8 acres or the actual pound has a trench 12′ wide × 9′ deep running all around it. This is located on the edge of the River and the entrance to it is guarded by a massive wooden gate. Adjoining the Khedda area, the Roping Stockade was constructed of four layers of wooden pillars tied together to form a stockade. On these were erected platforms from which the guests view the roping operation. In addition on the bank of the River on the side of the Khedda several platforms or sight-seeing spots were concealed. From these platforms the distinguished visitors watched the spectacular and final push of the herd up the river and into the Khedda without detection. Also over 100 miles of surround lines of 10 feet width were cleared in the forests and pegged at 2 chains apart. Each peg marks the place where fire-watchers were stationed and at each such spot enough firewood was stacked in advance.

These are roughly some of the preliminary arrangements to be made and take about 3–4 months of hardwork from August–November to complete.

The Geography of the Khedda and the important final phases of the operations are best described in the diagrams (enclosed).

The actual operations from the moment a suitable herd was spotted to the final stage when the captives were securely roped are described in the following paragraphs.

The final drive was scheduled for 28th December 1949, 2:30 p.m. and months ahead, daily reports of movements of herds were being received at Headquarters from professional trackers. A herd of elephants was finally detected within the larger surround area and this was surrounded on 14th December. The surround, which was now 16 miles all round, had to be guarded day and night by 800 men with blazing fires every 2 chains apart, and supervised by Forest Officers on patrol duty. The idea now is to hold the herd within this larger surround area until the moment when the preliminary drives commence.

By a series of drives between 17th December and 23rd December, the herd was moved in easy stages across the river and on to the opposite side of the Khedda area into a previously surrounded area. During these drives other game, tiger, bison, spotted deer and the like were seen, and these were let go. From the 23rd December until the eventful day the elephants were allowed to roam and feed peacefully within this rich bit of forest and also to bathe and drink in the fresh-clean waters of the Kabbani river.

Before the appointed hour the Driving Party, consisting of a few selected Forest Officers under the leadership of the Chief Conservator of Forests, mounted on elephants and a batch of men on foot also selected for boldness, had taken their position on the line, shown on the

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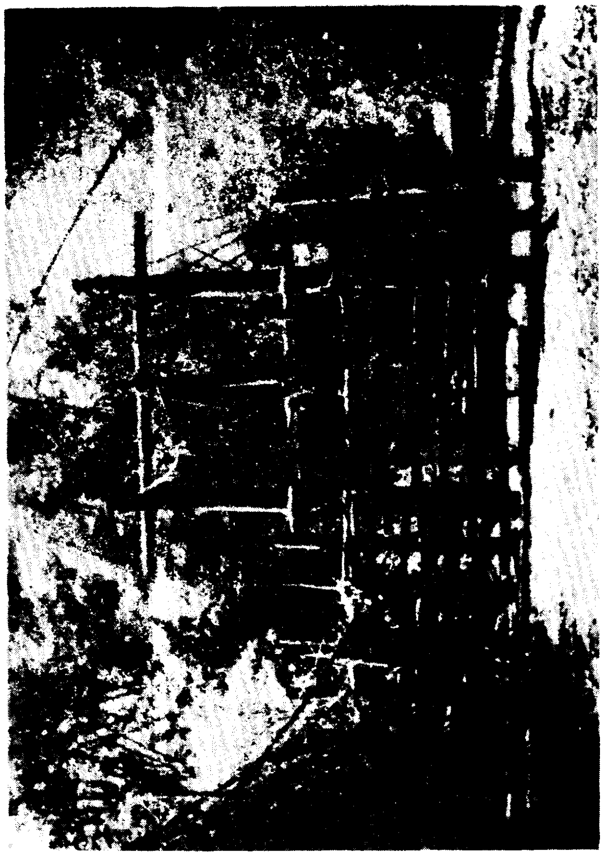

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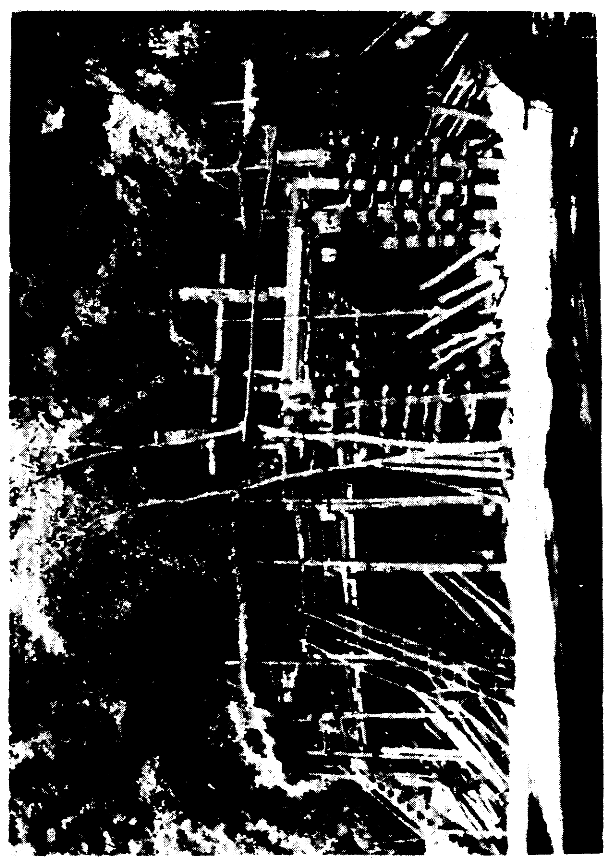

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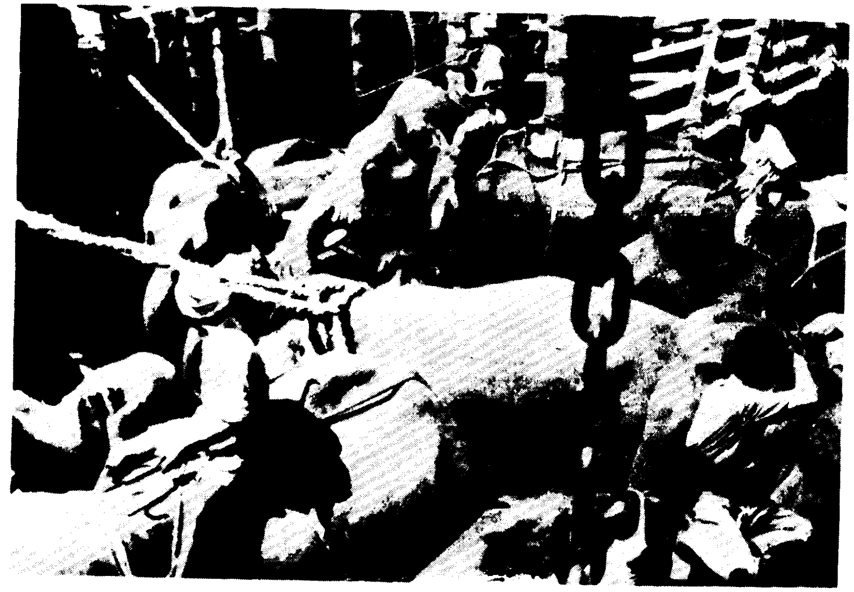

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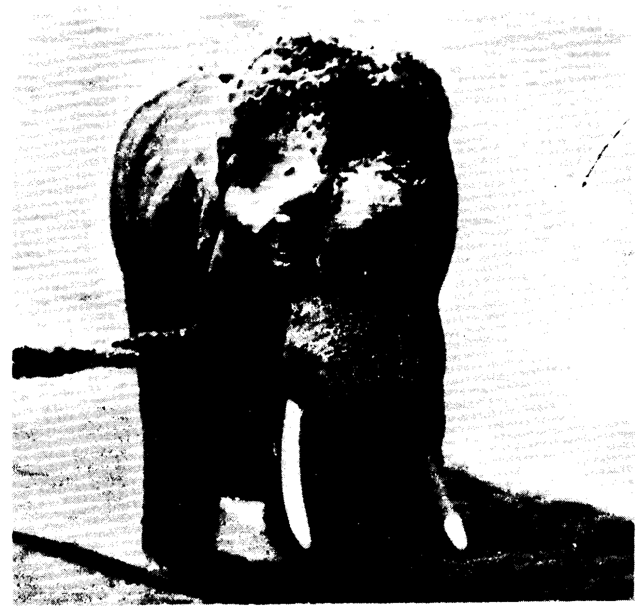

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Khedda map. On the Eventful day, the distinguished visitors, viz., His Highness the Maharaja of Mysore and Party, the Hon'ble the Minister for Labour with the Government of India, the Hon'ble Ministers from various Provinces and Mysore, the delegates to the International Labour Office Conference then in Session in Mysore and hundreds of others spectators were all ready on the various platforms. Exactly at 2:30 p.m., at the appointed moment, a telephone message was flashed to the Chief Conservator of Forests in the Jungle to commence the drive and immediately the great and final drive started with the sounds of bugles, loud and maddening yells from the beaters, beating of clappers and occasional gun reports. This was the great moment for which every Forest Officer all these months waited for with strained nerves and having come, it called for cool courage to execute the job. As the herd thus driven approached the bank of the River, having had its suspicions aroused, made desperate and futile efforts to break through the Driving Party but ultimately 40 elephants with many calves not even a few months old slid down into the River and the young ones started enjoying themselves in the water quite unware that the spectators were watching them with fascination and that newsreel camera was grinding away.

Once in the River it was not a difficult task to force them up the river through the massive gate into the Khedda. The visitors after witnessing this unforgettable scene were brought over to the roping stockade and from the specially constructed elevated platform watched the roping operations. Into the roping stockade now entered the Kumkies with skilled Mahouts who undertook this most dangerous operation in the full view of hundreds of spectators.

The Khedda operation of 1949 was acclaimed as successful and elegant. By timing the sequence of operations correctly, and by drafting just the required labour strength as and when needed, costs were cut down to a minimum. Roping was started within an hour of the final drive. And the last of the captured elephants had been sold away within 4 weeks of capture. By *careful planning*, the expenses were well within the sanctioned budget of Rs. 75,000 and the sale proceeds brought in Rs. 1,32,000 which showed a sizeable surplus. Some of the captured elephants were reserved by the Government of Mysore for their own use. Besides being eminently satisfactory from this angle, the operation gave the agriculturist much needed relief.

There is an interesting and a very exciting tail-piece to this account of the 1949 Khedda. On 23–1–50, the date fixed for the sale of the captives all of us, numbering over a hundred people, had assembled at the "Peelkhana"—a place where the captives were tied up. While we were examining the captives we were suddenly warned that a big solitary Tusker was approaching towards the captives. Quietly but hurriedly all but a few Officers and Mahouts were made to leave the place. Alas ! Just 100 yards from us we were amazed to see a huge and magnificent Tusker walking slowly but majestically towards us. We soon discovered that this was the same big Tusker, which had broken out of our surround a few days prior to the final drive and was undoubtedly the father of the herd. Now like a devoted and valiant father he had returned to his family—on the eve of their departure, and to share their doom—if necessary. This was a tense moment for all and decision had to be taken between 2 alternatives—whether to drive him out and turn him into a rogue or undertake a serious risk and capture him. The second alternative though highly dangerous was decided upon. Surprisingly enough, the daring Mahouts and Kumkies did capture the animal. This latest acquisition to the 1949 Khedda was sold on the spot for Rs. 10,000.

EXPLANATION OF PLATE I

Photo 1. The Khedda or the Trench surrounding the area.
,, 2. The massive wooden Gate guarding the entrance to the Khedda.
,, 3. The Roping Stockade.
,, 4. The Land drive in progress.
,, 5. The River Drive in progress.
,, 6. The Roping operation in progress.
,, 7. Kumkies leading the Captives to water.
,, 8. The Hero in Bondage.

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART I

Forests constitute our national wealth. To maintain our forests economically, is our first concern. Engineering structures of proper design and sound construction play a vital part in the economic exploitation of this national asset.

Though efficient timber bridges have been built in the past, according to ideas of strength then current, modern design has evolved improved methods of economy and efficiency, and it is desirable that these new methods be adopted. As timber is no longer in such plenty even in our forests as in the past, economy in timber is essential, provided designs are not complicated to such an extent as to offset the beneficial results of such economy. This article will show how to economize timber, without sacrificing cost or safety, of forest timber bridges ordinarily met with in practice. As forest timber bridges are restricted to comparatively small spans, we have selected the four spans mentioned above. Our available indigenous timber, much of which was considered unsuitable in the past (due to a liability to fungus and insect attack) for structural purpose, can now be made to last for long periods, even up to 35 years, by the adoption of methods of preservation and protection evolved at the Forest Research Institute, Dehra Dun. While timber is a very much more reliable material for constructional purposes than steel and concrete, it is also a much more economical material in first cost, and in the economics of long term forestry, in virtue of the multiplication of the cost when calculated over the long periods of rotations at compound interest on the capital cost, every initial economy is of importance.

It is of utmost importance to consider the following special points in the design of timber structures before commencing the actual calculations of different types of bridges :—

(1) *Type of loading.*—Mechanical properties of wood are considerably affected by the duration of loading. The shorter the time of loading the higher will be the strength. Thus for bending moment computation take in calculation double the weight of actual dead weight of material.

(2) Duration of loading affects the stiffness even more than the strength. Deflection under long-continued loads (e.g., dead weight of timber itself) may be 2 to 4 times its deflection under short-time load (e.g., live loads). Thus in calculating deflection of timber beams it is recommended that the dead load due to material of the beam should be taken 3 times.

(3) *Impact factor.*—Compared to other structural materials (e.g., steel) behaviour of timber under impact loading differs fundamentally. From tests of timber it has been established beyond doubt that resistance of timber to suddenly applied loads (e.g., moving loads on bridges) is much greater than its resistance to constant loading (e.g., dead load).

Thus safe working stresses should be used without adjustment of increased equivalent dead load as is commonly used for other structural materials (e.g., steel). That is to say no impact factor is taken into account in timber structures.

DESIGN OF ROAD BRIDGES

Note.—Indian Road Congress specification of 'B' class bridges confirms with ~~the~~ design of a road bridge to take a moving load of a 10-ton Road-roller passing one at a time over the bridge.

Indian Road Congress specification for 'B' class bridges with modifications in case of timber as materials of construction is as follows. The bridges in these articles are designed to take :—

A. For computing bending moment :

(i) 0·34 tons per linear foot of each traffic lane (the width of one traffic lane = 10 feet) see Fig. 1.

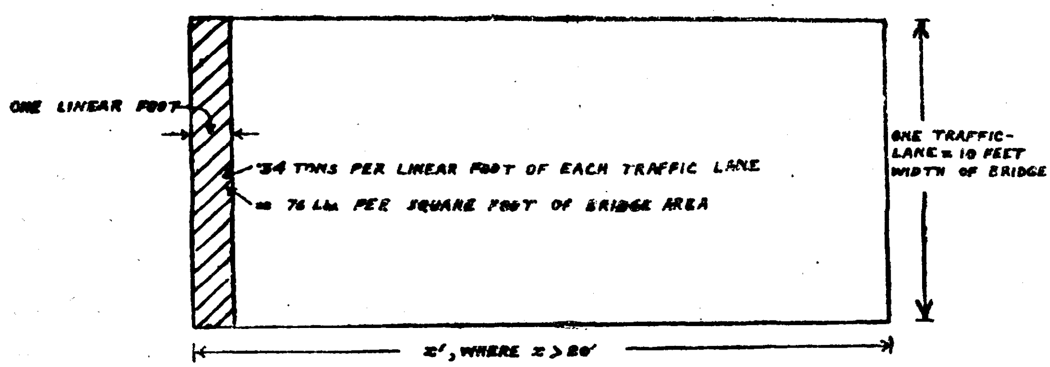


FIG 1

(ii) A knife-edge load of 6 tons per lane of traffic. See Fig. 2.

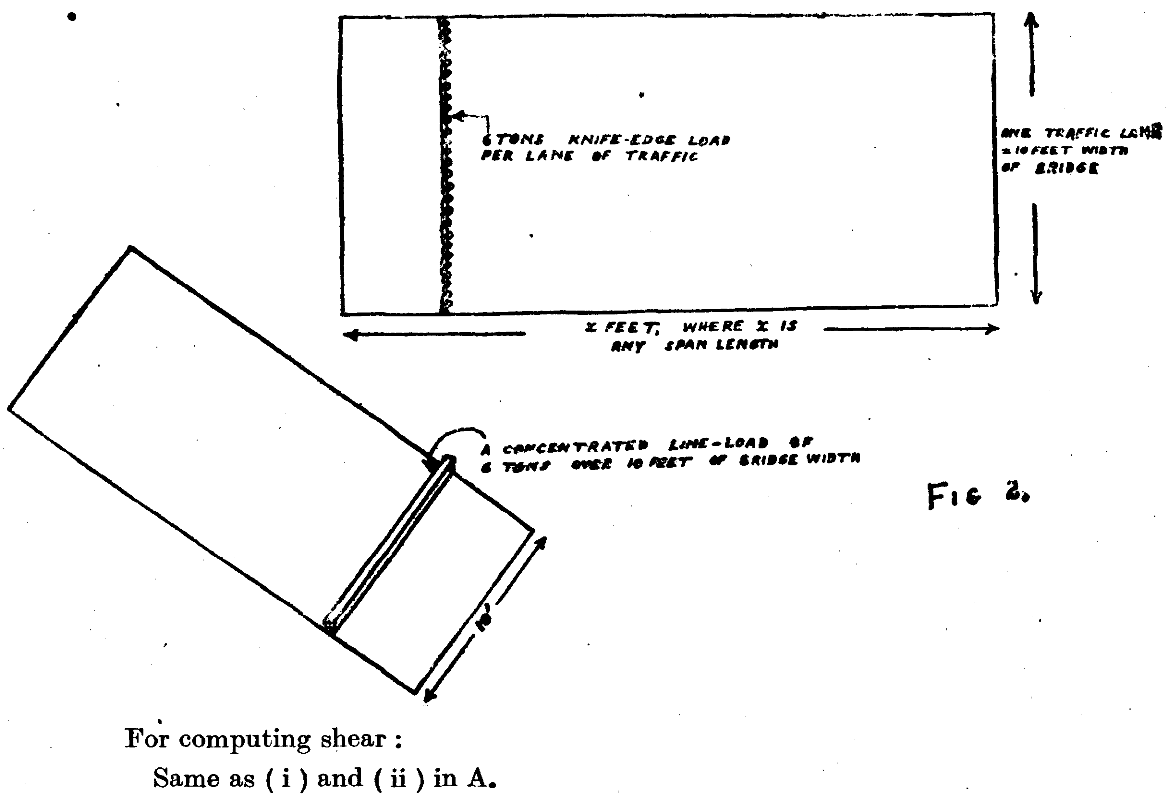


FIG 2.

For computing shear :

Same as (i) and (ii) in A.

B. Limitation is attached to specification (i) in A. That for bending moment computation, total distributed load on loaded lengths of 20 feet and under for single

lane of traffic shall never be less than 6·8 tons over the whole loaded length (i.e., span of bridge) for each traffic lane. See Fig. 3.

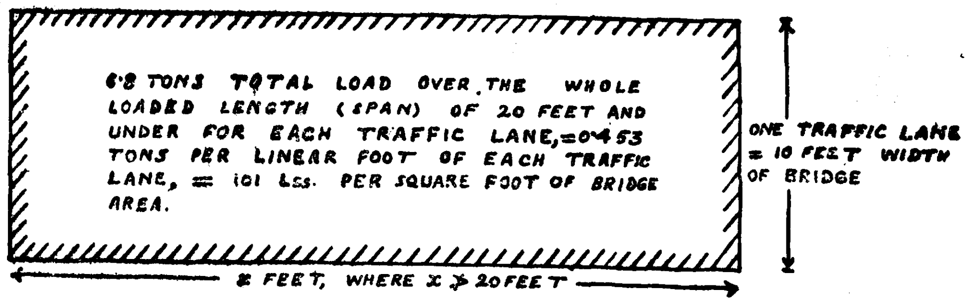


FIG. 3

Note for A and B.—If the bridge is more than one traffic lane in width, i.e., 10 feet wide but less than two traffic lanes, i.e., 20 feet wide, calculate proportional weight for extra width over 10 feet and base your design on it.

Design for a timber bridge of span 15 feet, class 'B' loading. Timber used is *sal* (*Shorea robusta*), grade of timber being structural No. 2, conforming to standard grade. Width of bridge is 10 feet.

Safe working stresses for structural No. 2 grade *sal* for outside locations (e.g., bridges) are as follows :—

(1) Extreme fibre stress for calculation of beam sizes
$= f_t = 2400$ lb. per sq. inch.

(2) Max. intensity of horizontal shear in beams
$= s_m = 180$ lb. per sq. inch.

(3) Compression parallel to grain for calculation of short columns
$= f_c = 1700$ lb. per sq. inch.

(4) Compression perpendicular to grain for calculation of bearing members
$= f_b = 900$ lb. per sq. inch.

(5) Modulus of elasticity $= E = 2 \times 10^6$ lb. per sq. inch.

(6) Weight of *sal* $= w = 60$ lb. per cu. feet.

As per limitation B (because our bridge span is $<$ 20 feet) A 1 becomes

$\frac{6 \cdot 8}{15} = 0 \cdot 453$ tons per linear foot of each traffic lane instead of 0·34 tons.

Thus for B.M. and shear computations, the design must take

(1) 0·453 tons per linear foot of each traffic lane. See Fig. 3.

(2) A knife-edge load of 6 tons per traffic lane. See Fig. 2.

DESIGN OF BRIDGE DECKING

Let the arrangement of Roadbearers and decking be as shown in Fig. 4.

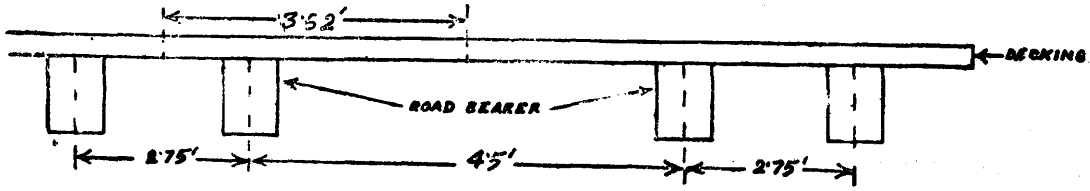


FIG. 4

(1) Take 12 inches as width of each plank for decking.

(2) Uniformly distributed dead load (U.D.D.L.) due to 0·453 ton per linear foot of each traffic lane on a span of 4′ — 6″ (see Fig. 4) is

$$W_1 = \frac{0 \cdot 453 \times 2240}{10} \times \frac{4 \cdot 5}{1} = 460 \text{ lb. approx.}$$

(3) Dead weight of decking itself of 4′ — 6″ length, 12 inches wide and say 4 inches thick is

$$\frac{4 \cdot 5}{1} \times \frac{1}{3} \times \frac{60}{1} = 90 \text{ lb.}$$

Considering long duration of dead weights (as mentioned previously) take double the weight of actual weight of material, i.e.

$$W_2 = 2 \times 90 = 180 \text{ lb.}$$

(4) $\therefore$ Adding $W_1 + W_2 = 460 + 180 = W$

$$W = 640 \text{ lb.}$$

(5) Bending moment due to 4 is

$$\text{B.M.}_{max} = \frac{WL}{12} \text{ (taking continuity of decking into consideration)}$$

$$= \frac{640 \times (4 \cdot 5 \times 12)}{12}$$

$$= 2880 \text{ in lb.}$$

(6) U.D.D.L. due to knife-edge load of 6 tons per traffic lane

$$W = \frac{6 \times 2240}{10} \times \frac{4 \cdot 5}{1} = 6048 \text{ lb.}$$

(7) B.M. Maximum due to 6 $= \dfrac{WL}{10}$

$$= \frac{6048 \times (4 \cdot 5 \times 12)}{10}$$

$$= 32{,}659 \text{ in lb.}$$

(8) Total max. B.M. $= 2880 + 32{,}659$

$$= 35600 \text{ in lb.}$$

(9) Now B.M. $= f_t \times Z$ (by simplified theory)

where B.M. = Bending moment maximum

f_t = Extreme fibre stress

Z = Modulus of section.

$Z = \dfrac{bd^2}{6}$ for rectangular beams where

b is width of beam in inches

d is depth of beam in inches.

$\therefore$ Substituting the values in 9 we have $35600 = 2400 \times \dfrac{bd^2}{6}$

Considering b = 12 inches as width of plank.

$$d^2 = \frac{35600 \times 6}{2400 \times 12} = 7 \cdot 4165$$

$$d = 2 \cdot 7 \text{ inches.}$$

Use main decking of 2·75 inches and over it at right angles place planks $1\frac{1}{2}$ inches thick nailed down to main decking to take wear and tear of traffic. The upper $1\frac{1}{2}$ inches planking can be renewed as and when required.

Test of decking against shear :

(1) Maximum shear due to $0 \cdot 453$ tons per linear foot of each traffic lane is

$$S_{max} = \frac{640}{2} = 320 \text{ lb.}$$

(2) Shear due to 6 tons per traffic lane is

$$S_{max} = \frac{6 \times 2240}{10} \times \frac{4 \cdot 5}{1} \times \frac{1}{2} = 3040 \text{ lb.}$$

(3) Total shear S $= 320 + 3024 = 3344$ lb.
$= 3350$ lb. (approx.).

(4) Now $\frac{S}{A} = s_a =$ permissible average shear stress for *sal.*

$A =$ Area of section for decking
$= 3 \cdot 5'' \times 12'' = 42$ sq. inches

$$\therefore \frac{3350}{42} = s_a = 80 \text{ lb. per sq. inch.}$$

But maximum intensity of shear stress 's_m' for a rectangular beam is

$$\frac{3}{2} s_a \text{ i.e., } s_m = \frac{3}{2} \times \frac{80}{1} = 120 \text{ lb. per sq. in.}$$

This is less than permissible max shear stress of 180 lb. per sq. in. allowed for *sal.* See Fig. 5.

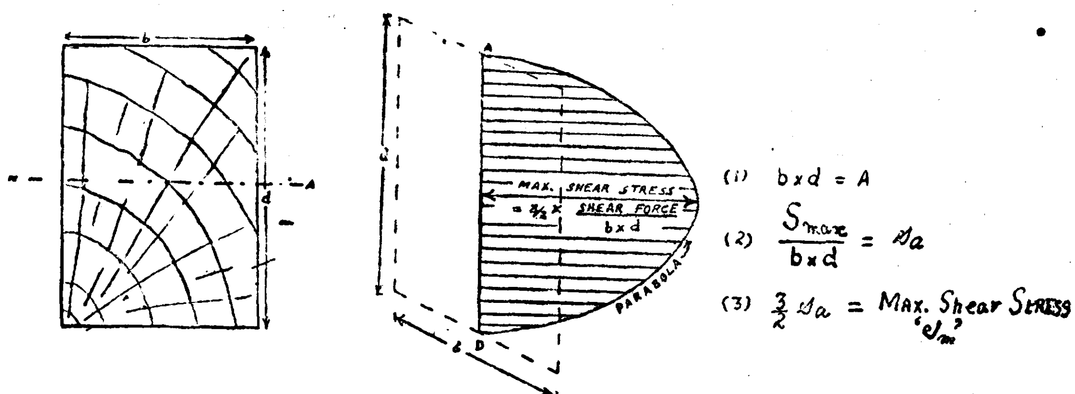


FIG 5

DISTRIBUTION OF SHEAR STRESS OVER SECTION OF BEAM

Hence the section of decking is safe against shear.

Test of decking against deflection :—

Allowable deflection in bridge members is $\frac{1}{240}$th of the span.

Hence deflection allowed in case of 15 feet span bridge

$$= \frac{1}{240} \times \left(\frac{4 \cdot 5}{1} \times \frac{12}{1} \right) = 0 \cdot 225 \text{ inches.}$$

Now actual deflection coming on the decking is due to

δ_1 on account of $0 \cdot 453$ ton per linear foot of each traffic lane.

δ_2 on account of 6 tons due to knife-edge load per traffic lane.

δ_3 on account of three times the dead load due to material of decking. (As mentioned previously).

$(\delta_1 + \delta_3)$ is given by equation $\frac{5}{384}\ \frac{WL^3}{EI}$ due to distributed load condition.

where $W = 460 + 3 \times 180 = 1040$ lb.

$L = 4 \cdot 5$ feet.

$E = 2 \times 10^6$ for *sal.*

$I = \frac{bd^3}{12}$ where $b = 12$ inch (assumed)

$d = 3 \cdot 5$ inch (calculated previously).

$$\therefore (\delta_1 + \delta_3) = \frac{5}{384} \times \frac{1040 \times (4 \cdot 5 \times 12)^3}{2 \times 10^6 \times 64}$$

$= 0 \cdot 0166$ inches.

Again $\delta_2 = \frac{1}{48}\ \frac{WL^3}{EI}$ due to concentrated load, where $W = 6048$ lb.

$$\therefore \delta_2 = \frac{1}{48}\ \frac{6048 \times (4 \cdot 5 \times 12)^3}{2 \times 10^6 \times 64}$$

$= 0 \cdot 155$ inches.

$\therefore$ Total deflection $= (\delta_1 + \delta_3) + \delta_2$

$\therefore \quad \delta = 0 \cdot 0166 + 0 \cdot 155$

$\therefore$ actual $\delta = 0 \cdot 1716$ inches.

This actual deflection of $0 \cdot 1716$ inch is less than permissible deflection of $0 \cdot 225$ inch. Thus section of decking is safe against deflection also.

DESIGN OF ROADBEARERS

Let the arrangement of roadbearers be as in Fig. 4.

1. U.D.D.L. due to $0 \cdot 453$ ton per linear foot of each traffic lane over a span of 15 feet and $3 \cdot 62$ feet width (see Fig. 4) is

$$W_1 = \frac{0 \cdot 453 \times 2240}{10} \times \frac{15}{1} \times \frac{3 \cdot 62}{1} = 5484 \text{ lb.}$$

2. Dead weight of decking $= 15 \times 3 \cdot 62 \times \frac{3 \cdot 5}{12} \times \frac{60}{1}$

$W_2 = 950$ lb.

Considering prolong duration of dead load (as mentioned previously)

$W_2 = 2 \times 950$

$= 1900$ lb.

3. Dead weight of roadbearer assuming it to be $12'' \times 6''$ section

$= \frac{72}{144} \times \frac{15}{1} \times \frac{60}{1}$ i.e., $W_3 = 450$ lb.

Considering prolong duration of dead load

$W_3 = 2 \times 450 = 900$ lb.

4. Therefore total distributed dead load on one roadbearer is

$W = W_1 + W_2 + W_3$

$= 5484 + 1900 + 900$

$= 8284$ lb.

5. $\therefore$ Max. B.M. $= \frac{WL}{8}$ (due to distributed loads)

$$= \frac{8284 \times (15 \times 12)}{8} = 186{,}390 \text{ in. lb.}$$

6. U.D.D.L. due to knife-edge load of 6 tons per traffic lane is

$$W = \frac{6 \times 2240}{10} \times \frac{3\cdot 62}{1} = 4865 \text{ lb.}$$

7. $\therefore$ Max. B.M. due to 6 $= \frac{WL}{4}$ (due to concentrated load).

$$= \frac{4865 \times (15 \times 12)}{4}$$

$$= 218{,}925 \text{ in. lb.}$$

8. Total max. B.M. due to 5 and 7 is

$$\text{B.M.}_{max} = 186{,}390 + 218{,}925$$
$$= 405{,}315 \text{ in. lb.}$$

9. Assuming width of roadbearer to be 6 inches

Then B.M. $= f_t \times Z$

$\therefore$ $405{,}315 = 240 = \frac{bd^2}{6}$

$$d^2 = \frac{405315 \times 6}{2400 \times 6} = 168\cdot 8$$

$\therefore$ $d = 12\cdot 99$ inches.

$\therefore$ Use section of roadbearers 13″ depth and 6 inches width.

Testing of roadbearers against shear :

1. Max. shear due to $0\cdot 453$ ton per linear foot of each traffic lane

$$S_{max} = \frac{5494}{2} = 2742 \text{ lb.}$$

2. Max. shear due to 6 tons per traffic lane

$$S_{max} = \frac{6 \times 2240}{10} \times \frac{3\cdot 62}{1} = 4865 \text{ lb.}$$

3. Max. shear due to dead weight of decking and roadbearer is

$$S_{max} = \frac{(950 + 450)}{2} = 1400 \text{ lb.}$$

4. Total max. shear $= 2742 + 4865 + 1400$

$\therefore$ $S = 9000$ lb. (approx.).

5. Now $\frac{S}{A} = s_a$ where s_a = permissible average shear stress for *sal*.

A = Area of roadbear section

$= 13 \times 6 = 78$ sq. inches.

S = 9000 lb.

$\therefore$ $S_a = \frac{9000}{78} = 115$ lb. per sq. inch (see Fig 5).

6. Max. intensity of shear stress 's_m' $= \frac{3}{2} s_a$

$$= \frac{3}{2} \times \frac{115}{1}$$

$$= 172 \text{ lb./sq. in.}$$

7. This 172 lb. per sq. in. is less than permissible max. intensity of shear stress of 180 lb. per sq. inch allowed for *sal*.

Hence the section 13″ × 6″ of Roadbearer is safe against shear.

Testing of Roadbearer against deflection :—

$$\text{Allowable deflection} = \frac{1}{240}\text{th of the span.}$$

$$= \frac{1}{240} \times \frac{(15 \times 12)}{1}$$

$$= 0{\cdot}75 \text{ inches.}$$

Now actual deflection coming on the roadbearer is due to

δ_1 on account of 0·453 ton per linear foot of bridge

δ_2 on account of 6 ton knife-edge load per traffic lane

δ_3 on account of three times the dead load due to material of decking and roadbearer (as mentioned previously)

$$(\delta_1 + \delta_3) = \frac{5}{384}\ \frac{WL^3}{EI} \quad \text{(distributed load condition)}$$

where $W = 5484 + (3 \times 950) + (3 \times 500) = 9834$ lb.

$L = 15$ feet

$E = 2 \times 10^6$ for *sal*

$$I = \frac{bd^3}{12} = \frac{6 \times 13^3}{12} = 1098{\cdot}5 \text{ in}^4.$$

$$\therefore\ \delta_1 + \delta_3 = \frac{5}{384} \times \frac{9834 \times (15 \times 12)^3}{2 \times 10^6 \times 1098{\cdot}5}$$

$$= 0{\cdot}34 \text{ inches (approx.)}$$

$$\text{Again } \delta_2 = \frac{1}{48}\ \frac{WL^3}{EI} \quad \text{(for concentrated load condition)}$$

where $W = 4865$ lb.

$$\therefore\ \delta_2 = \frac{1}{48} \times \frac{4865 \times (15 \times 12)^3}{2 \times 10^6 \times 1098{\cdot}5}$$

$$= 0{\cdot}26 \text{ inches (approx.)}$$

$\therefore$ Total max. deflection $= (\delta_1 + \delta_3) + \delta_2$

$\therefore$ $\delta = 0{\cdot}34 + 0{\cdot}26$

$\therefore$ actual max. $\delta = 0{\cdot}6$ inches.

Since actual max. deflection of 0·6 inch is less than permissible deflection of 0·75 inch therefore section of 13″ × 6″ Roadbearer is safe against deflection.

TABLE I

Timber required is as follows

A complete statement in Tabular form of a Bridge 15 feet span, 10 feet traffic width, made of sal timber of structural grade No. 2

Serial No.	Name of Items	Section b × d	Sectional area per piece	Legth per piece	Cu. ft. per piece	Number of piece required	Total cu. ft. required	Remarks cons-tructional	Serial No.
		in. × in.	sq. in.	ft. in.	Cu. ft.	Nos.	Cu. ft.	See footnote	
1	Decking of sal sleepers { Main Deck .. { Wearing Deck ..	12×2·75 12×1½	33 18	12 0 10 0	2·75 1·25	15 15	41·25 18·75	1*a*, 1*b* and Figs. 6 and 7	1
2	Roadbearers or stringers ..	6×13	78	16 0	9·00	4	36·00	2*a*, 2*b*	2
3	Bridge seat ..	6×3	18	13 0	1·60	2	3·20		3
4	Solid strutting or spacers ..	4×6	24	4 0 } 2 3 }	0·60 } 0·38 }	2 4	1·20 1·52		4
5	Guard blocks ..	5×3	15	0 6	0·05	10	0·50	5*a*	5
6	Wheel guards or Ribbonds ..	5×4	20	15 0	2·08	2	4·16		6
7	Rail posts ..	5×4	20	4 0	0·55	8	4·40		7
8	Hand Rails ..	3×4	12	15 0	1·25	4	5·00		8
9	Inclined struts for Bracing Rail posts	3×3	9	5 0	0·38	8	3·04		9

Total cu. ft. of timber = 119·02.

NOTE ON REMARKS—TABLE I

(1*a*) At the position of Rail posts which is 5 feet centre to centre carry the decking sleepers further outwards by 18 inches to receive the feet of inclined struts; heads of inclined struts are housed and bevelled to rail posts (see Figs. 6 and 7).

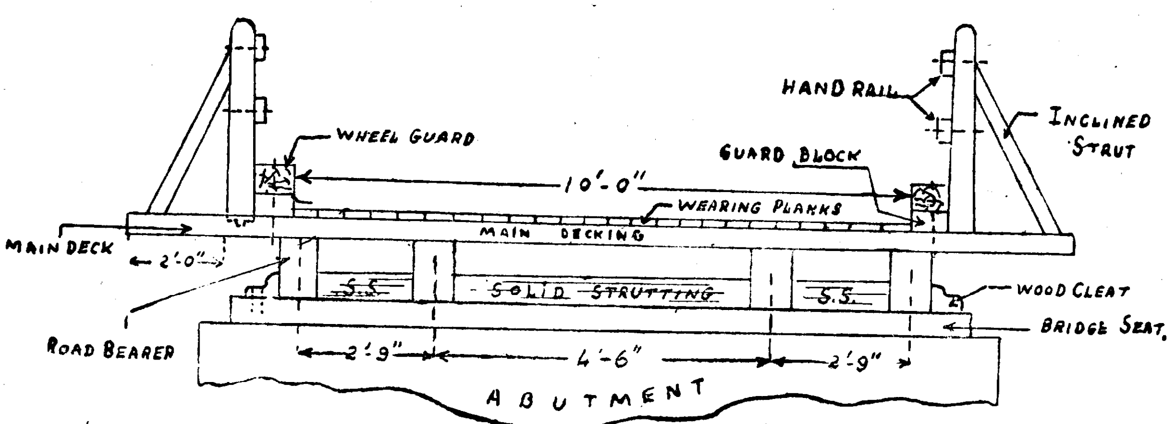


FIG 6

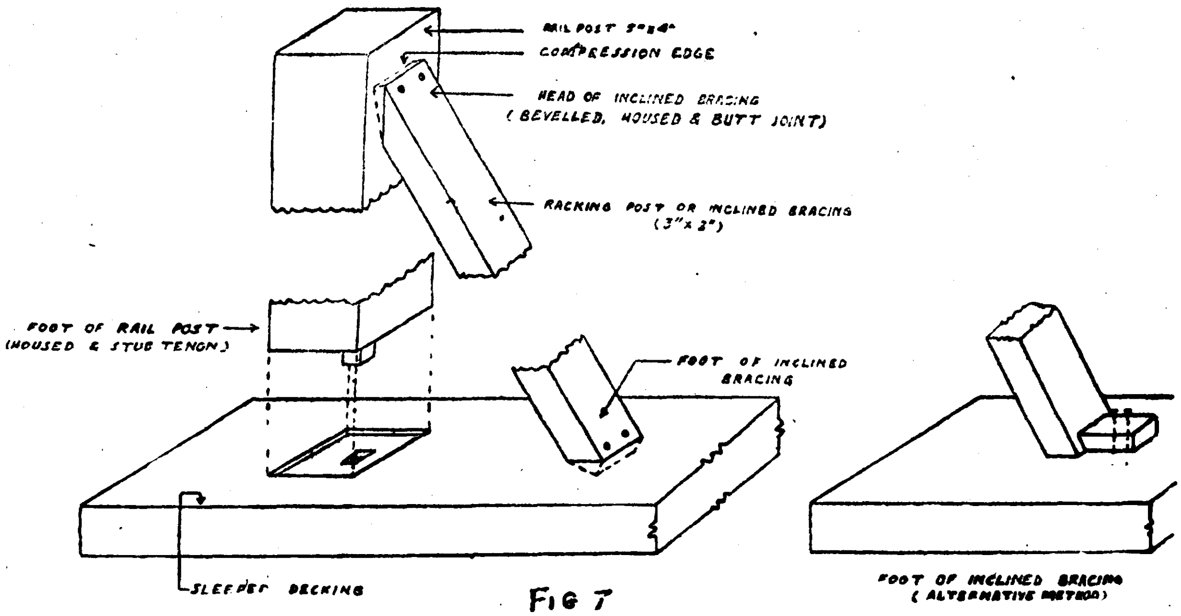


FIG 7

(1*b*) Over the main decking sleepers nail $1\frac{1}{2}$ inch thick *sal* planks at right angles or diagonally to main decking to take up wear and tear. In case of renewals these wearing planks are replaced when worn out.

(2*a*) Let the roadbearer rest over bridge seat at their two ends. The bridge seat consists of *sal* sleepers 3″ × 6″ section.

(2*b*) Use spacers or distant pieces at abutment ends to maintain correct spacing between roadbearers and also prevent toppling over of roadbearers.

(5*a*) These are placed at 5 feet intervals. They allow an opening of 2″ on both sides of the rail and throughout the bridge length for easy drainage of water over the carriage way of the bridge. (Figs. 9 and 10).

TABLE II.

Hardwear required for 15 feet span Girder Bridge

Serial No.	To connect	Bolts and Nuts			Iron washers			Nails 3″ long and $\frac{3}{8}$″ diameter	Spikes 6″ long $\frac{1}{4}$″ diameter	Remarks constructional	Serial No.
		Diameter inches	Length inches	Numbers required	Thickness inches	Diameter inches	Number required				
1	1-inch planking with main decking	..	..	..	..	..	..	110	..	1*a*	1
2	Main decking to Roadbearers ..	..	..	..	..	..	..	..	120	2*a*	2
3	Roadbearers to Bridge seat ..	$\frac{3}{4}$ Drift bolt	10	8	$\frac{1}{4}$	2	16	..	..	3*a*, Figs. 8 and 6	3
4	Guard block and Wheel Guard to main Decking ..	$\frac{3}{4}$	12	10	$\frac{1}{4}$	2	20	..	..	..	4
5	Rail post to main Decking ..	..	..	..	..	..	..	..	..	5*a*, Fig. 7	5
6	Hand Rails to Rail post ..	$\frac{1}{2}$	9	16	$\frac{1}{8}$	1·25	32	..	..	6*a*, Fig. 6	6
7	Inclined strut to Rail post and Decking	..	..	..	..	..	..	..	16	7*a*, Fig. 7	7

NOTE ON CONSTRUCTIONAL REMARKS—TABLE II

(1a) Wearing planks nailed to main decking every two feet longitudinally and laterally with a pair of nails.

(2a) Main decking fastened to roadbearers with two 6″ wire spikes at each roadbearer per decking.

(3a) Each of the end roadbearers secured to bridge seat through timber side cleats secured by two drift bolts. (See Fig. 8).

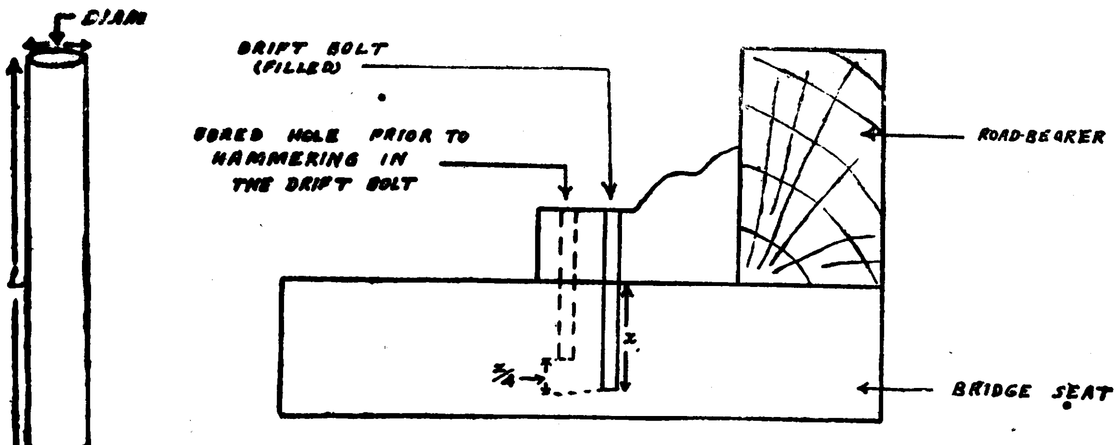


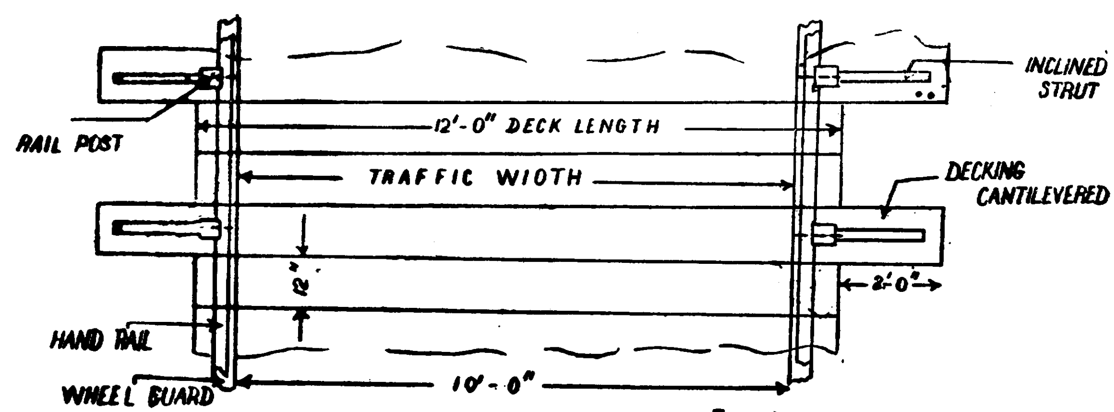
FIG 8.

Intermediate roadbearers are kept in position by spacers or solid strutting. (See Fig. 6).

(5a) Make a stub-tenon and housed joint with the main decking. (See Fig. 7).

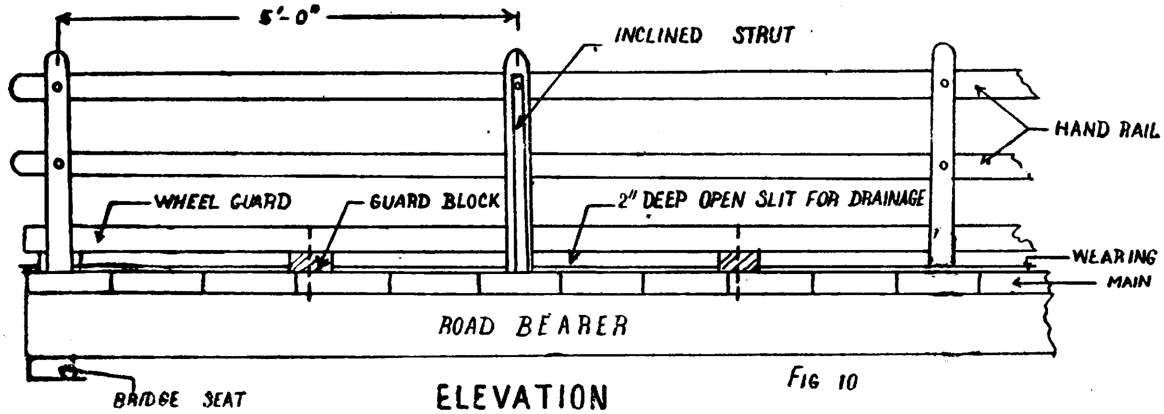
(6a) Fix hand rails on the inner side of the rail post with one bolt at every intersection with the post. (See Fig. 6).

(7a) Foot of inclined strut obliquely notched to the cantilevered decking and spiked by a 6″ nail in addition. (See Figs. 7, 9 and 10).



PLAN

FIG 9



Head of inclined strut housed, bevelled, butt and spiked by a 6″ nail to rail post. (See Fig. 7).

GENERAL REMARKS ON HARDWEAR

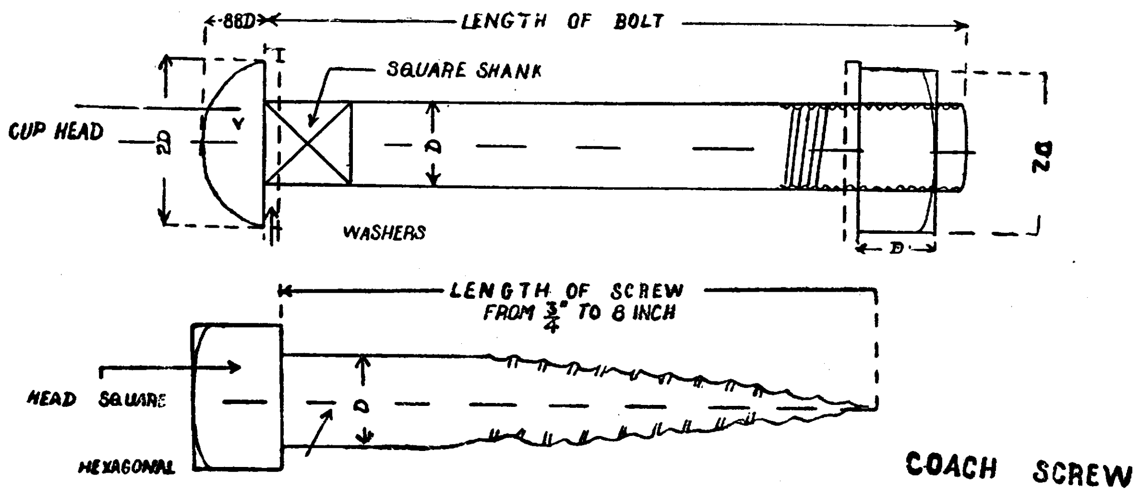
Bolts and nuts.—(See Figs. below):

(*a*) Depth of nut is usually equal to diameter of bolt.

(*b*) When estimating length of bolt required an allowance for one nut and two washers must always be made.

(*c*) Bolts and nuts must be retighted after the timber has shrunk.

(*d*) Diameter of hole to take in bolt should be $\frac{1}{8}$ inch larger than the diameter of bolt.

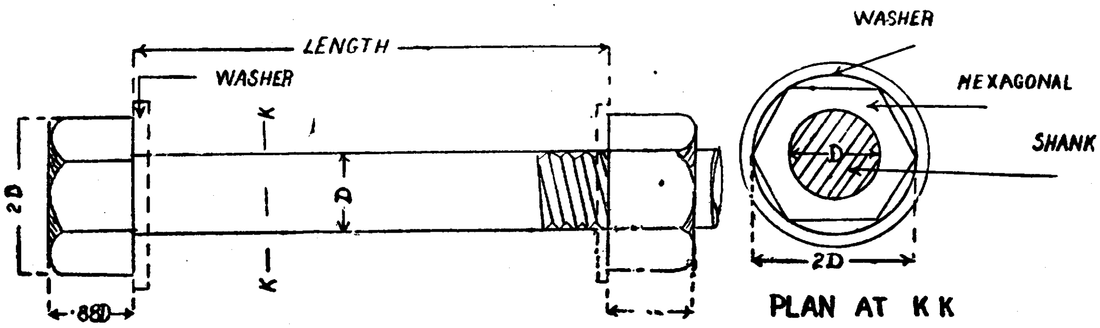


Iron washers.—

(*a*) Thickness of washers $\frac{1}{8}$ diameter of bolt generally.

(*b*) They are placed one under bolt head and another under nut to increase the bearing surface and thus preventing crushing of timber fibres under bolt head or nut.

(*c*) Diameter of washers at least $2\frac{1}{2}$ times diameter of bolt used.



X O X

BOLT & NUT

Note :—Length of bolt in figure is wrong. It should be from inside bolt head to end of shank.

Drift bolts.—

(*a*) Round iron pieces without heads or points.

(*b*) They are driven like spikes into holes previously bored in the timber.
Diameter of hole to be bored to receive a drift bolt should be 4/5 of the diameter of drift bolt.

The hole is bored completely through the upper timber and into the lower timber for a depth of $\frac{3}{4}$ of the distance to which the bolt will finally penetrate. (See Fig. 8).

Spikes.—

Wire nail or wrought iron spikes to be used. To join two pieces of timber, make auger holes slightly smaller than the size of spikes through the first piece of timber only. The spikes should force their way into the second connecting piece of timber.

[*Continued*

With acknowledgment to AIR., New Delhi

TREE PLANTING FESTIVAL

BY HON'BLE SHRI K. M. MUNSHI

I propose to speak to you to-night of the Vana Mahotsava, the Festival of Forest, which is going to be celebrated throughout India from the 1st of July to the 7th of July. The Government of India and all the State Governments have decided to celebrate this Vana Mahotsava as the national festival of great importance. I stated in Bombay that like "Men of Trees" in modern Canada, we should honour and study and worship the trees. Let those who like to revive the echoes of Vrindavan with flute and rhythm. Let women and children gaily-dressed repair to the woods and dance and sing. Like unto maidens of classical times they may lovingly kick the Asoka tree or water the trees if they like, for trees are life.

I am very glad to find that my appeal to celebrate this festival has found echoes in the hearts of our countrymen. The Indian Merchants Chamber of Bombay have already undertaken to provide 10,000 trees in Dehotsarga, the place where Lord Shri Krishna 'shuffled off his mortal coil'. Delhi is also helping to plant 2,000 trees round the Samadhi of the Father of the Nation. On the 1st of July at 8·30 a.m. our beloved President will inaugurate the festival by planting a tree at Rajghat. The Prime Minister, the Deputy Prime Minister and other Ministers will also take part. I am glad to find that some of the Foreign Embassies too have expressed a desire to participate in the 'Festival of Forest' by planting trees at the Samadhi on the same day. Preparations, I understand, are also going on for planting trees at Brindavan, at Conjeevaram, ancient Kanchi, at Tirupati, at Jagannath Puri and Cape Comorin. The Heads of all the States as also their Chief Ministers and Ministers will, I hope, inaugurate the festival on the 1st of July in their respective capitals. The Vice-Chancellors of the Universities in India have also written to their colleges to participate in the 'Vana Mahotsava'. I, therefore appeal to all my young friends in the different colleges in the country to plant one tree each in their colleges during the week so that future generations of students might look back with pride upon the achievement of their forerunners who participated in the 'First Festival of Forest' in this country.

It is not merely a romantic love for festivals that made me decide upon a 'Vana Mahotsava'. The whole attention of the world has been fixed on the need of afforestation. It is the most constructive and peaceable enterprize in which all nations can co-operate to stop and reverse the advance of the deserts upon the good lands of the globe and thus relieve the growing shortage of food. The World Charter for Forestry Luncheon held two years ago cabled to the President of the United Nations Organization in the following terms :—

> "THAT, realizing in face of the present world famine the dependence of Man on trees and forests, and, seeing the forests disappearing and the deserts encroaching on the remaining food sources at a rate of up to thirty miles per year on thousand mile fronts in three Continents, this gathering of national representatives of twenty-four countries request the aid of the United Nations Organization in the preparation of a World Charter for Forestry".

Now what is said here of the world is more true of India. As I look at India of to-day, I am alarmed of the rapid disappearance of the forests. The War was responsible for the destruction of some of our previous forests. Mount Abu, one of the good health resorts, is now denuded of its forest and is hotter than before. A friend of mine who stayed recently at Ooty writes "Ooty which having been once the most picturesque Hill Station in India, is now so denuded of trees that many of the hills which were covered with Blue Gum, Red Gum, and other magnificent trees are bare except for the seasonal potato crop". We must, therefore, bring back the green glory of the forests.

In order to encourage people to take part in the 'Vana Mahotsava' there will be three All-India prizes for the best effort for growing trees during this week. The first prize will be given to the district which puts forward the highest successful effort in planting trees during

the coming festival. The second prize will be for the Institution which puts forward similar successful efforts to plant trees during the week. And the third prize will be to the individual who makes a similar successful effort. And I hope the whole country will participate in this competition and ultimately earn the reward of these prizes.

There is one other thing which I should also like to add to my appeal. If the 'Vana Mahotsava' is to be celebrated in the proper spirit, every one in India should during the Mahotsava week live on vegetables, fruits and tubers. We must pay our homage to the forests by eschewing articles of food other than those falling under the three classes which are closely associated with forests. In that way alone shall we show our love for the forests. At any rate I hope every patriotic Indian will during this week eschew cereals. If we can live with the aid of forests, why become a slave to foreign bread. We must achieve the New Freedom, the freedom from foreign bread.

I love trees so much that I cannot help being a little romantic. We cannot forget the loveliness of the blossoming fruit trees ; of the noble dignity of venerable trees ; of forests which like ancient Rishis live but to save mankind ; of the richness, plenty and happiness which they bring ; of the joy which would be ours, if every man and woman like Parvati reared a tree with parental affection ; and if every village and town enveloped itself in groves of verdent beauty. Let us do it and turn India into something of which we can be proud and in which the green glory of the forests will be there for every one to see how India enjoys her freedom under Swaraj.

FORESTRY, FOREST INDUSTRIES AND FOREST PRODUCTS RESEARCH IN AUSTRALIA

BY DR. S. KRISHNA

The entire land area of Australia covering nearly three million square miles is divisible into 4 well defined regions, viz.—

(*a*) The Great Plateau—most of which is level, its Central part getting a rainfall of 10″ or under. No forests exist here, only grazing lands.

(*b*) The Central Basin—which is a lowland area covering some seven hundred thousand square miles, mostly under orchards, wheat and pastures. In this southern section runs the Murray river.

(*c*) The Eastern Highland Strip—which is about 100 miles wide running along the eastern coastline. The strip contains most of the forests.

(*d*) The Coastal Plains—which is built up of soils carried down from the mountains forming a rim round most of the continent. These plains are very fertile and have good forests.

Sixty-seven per cent of the total area of Australia has a rainfall of under 20 inches per year. The heaviest rainfall occurs in the north coastal ranges of Queensland where as much as 250″ has been recorded, and on the Tasmanian West Coast (100–125″). Summer rains predominate in North Australian latitudes and winter rains in the south. Much of the Central Basin lies between the summer and winter rainfall. The most reliable regions are in the south and south-east where 50–75″ of rain falls, fairly uniformly throughout the year. These areas are consequently the most fertile and thickly populated.

The bulk of the timber supply comes from the thickly forested areas in the 40–75″ rain belt lying within and south of the tropics, along the east coast of Victoria, to Tasmania, and to the extreme SW. corner of W. Australia. These areas being also the richest agricultural lands and grazing soils, have gone under "settlement" with consequent denudation of much of the forests. Of the six Australian States, Tasmania, Queensland, and West Australia produce more timber than is needed locally but here too the surplus is decreasing rapidly.

Of nearly 3 million square miles of the land area only 124,000 sq. miles are under forests. (New South Wales 19,360 ; Victoria 27,020 ; Queensland 27·050 ; South Australia 10·500 ; West Australia 27·150 ; and Tasmania 12·900). Of these 75 per cent are state forests and the rest commercial or private. 44 per cent are exploitable forests, 21 per cent potentially exploitable and the balance covered with indifferent woods. Of the total natural forests 90·5% is hardwood, 7·9% softwoods, and 1·6% mixed. The hardwoods consist mainly of eucalyptus the famous Australian gums.

In 1944–46 the production of all saw-mills amounted to 131 million c. ft. hardwoods and 30·5 million c. ft. softwoods. In 1947–48, the production was still higher on account of the demand for more houses.

The hardwoods come from the genus *Eucalyptus*, in about 60 species, amongst which the most prominent are Jarrah (*E. marginata*) black butt (*E. pilularis*) mountain ash (*E. regnans*) stringybark (*E. obliqua*), spotted gum (*E. maculata*), alpine ash (*E. gigantea*), Karri (*E. diversicolor*), river red gum (*E. rostrata*), iron bark (*E. paniculata*), tallow wood (*E. microcorys*), blue gum (*E. tereticornis*), and flooded gum (*E. grandis*). The softwoods are mainly hoop pine and bunya pine (*Araucaria cunninghamii* and *A. bidwillii*), Cypress pine (*Callitris glauca*) and radiata pine. The cabinet woods are the following :— Celery top pine, Kauri pine (*Agathis palmerstoni*), Queensland maple (*Flindersia bravleana*), silver ash (*Flindersia pubescens*), silver silk wood (*Flindersia acuminata*) red cedar (*Cedrela australia*), walnut (*Eudiandra palmerstonii*) silky oak (*Cardwellia sublimita*), and coachwood (*Ceratopetalum apetalum*).

Magnificent virgin forests exist in several of the States and it is a delight to visit them. The forests are thickly populated and the trees are straight like organ pipes, more than 150 feet in height. Much has been said of the pre-eminent quality of the prime hardwoods of Tasmania ; indeed they rank with the finest in the world producing, in some areas as much so 150,000 super feet of timber per acre.

SOFTWOOD PLANTATIONS

The most significant fact in Australian timber economy is that Australia does not and cannot yet produce its timber requirements in full. In 1946–47 Australia imported 125 millions s. ft. of softwoods. In addition, she imported about 4/5th of her newsprint and a large proportion of other paper requirements. Consequently, throughout Australia the present time is one of stock taking, and of searching for information of new forest resources.

The question of afforestation, particularly of softwoods is therefore, one of the major questions with Australian foresters. They have, to an extent succeeded in this direction. After trying numerous species of pine, they have been successful with a few, particularly *Pinus radiata*, which they have been able to raise on unattractive and poor limestone soils, and in regions where the rainfall is under 25 inches. In South Australia, at Nangwaree, about 20 miles. from Mt. Gambier, stands 120,000 acre plantation of radiata pine. This is being increased to 200,000 acres. Working on a 40 years cycle they expect to exploit 5,000 acres a year. Radiata pine is planted $8' \times 8'$ and at 30 years' age, an acre is expected to yield 120,000 s. ft. (?) per acre. The land on which the plantation stands is poor but with a dressing of zinc dust (7 lb. per acre) it has responded beautifully. Rejuvenation of the soil is sometimes brought about to regenerate the eucalyptus also. For example, in W. Australia, where Jarrah, the teak of Australia, grows on laterite soils, it fails to regenerate naturally. But a dressing with a hundred-weight of superphosphate, 7 lb. of zinc dust and 7 lb. of copper sulphate brings about a remarkable change. I think we should try this on some of our sal soils which fail to regenerate this valuable species. May be, this will be effective also in curing the spike disease in sandal tree. At Glass House mountain, some 50 miles from Brisbane, experimental plantation of hoop pine, Carribean pine and theda pine have been raised on 6,500 acres. All of these have been successful and the expansion of the plantation is under way. The programme of planting softwoods is being pursued in all the states.

SILVICULTURE

Forestry, especially scientific forestry, is comparatively new in Australia, and in some states not quite 30 years old. Hitherto, only virgin forests were being exploited, and the question of natural regeneration did not seriously arise. It is only during the past 15 years that the shortage of timber is beginning to be felt, hence the need for systematic exploitation. Even to-day, silviculture is confined to making of surveys, reservation of adequate seed trees disposal of logging debris, fire protection, plantation techniques for softwoods, etc., though here and there some studies on plant physiology, nutrition with reference to minor elements and genetics, have also been made.

All forest areas are not yet opend out by roads, consequently the need for aerial surveys

has been felt. Considerable progress, however, has been made in developing methods of forest quality classification by the interpretation of aerial photographs. The work now goes beyond the mere mapping of forest types. Mature eucalyptus forests for example, are mapped in 4 height classes, and 5 density classes, as a general rule, but special classes are also established for unusually tall or dense stands.

The standard classes mapped by photo interpretation are :—

Heights of dominant trees	Density of the number of mature trees per acre
180 ft. and over	over 15
136–180 ft. ..	10–15
90–135 ft. ..	5–10
Under 9 ft. ..	1–5

These classes are further dissected to give over-mature (i.e., deteriorating) stands, fire damaged areas, and forests with rain-forest stories. Each state has its own forestry department and in recent years they have expanded their activities.

Forest Products Research

In Australia the land under forest is small in comparison with the total land area, consequently the timber supply is inadequate for the growing requirements of the population. The enthusiasts for metal and plastics would have us believe that the day of wood buildings and wood furniture has about reached its end, the modern world would cease to use wood for general purposes. This is an exaggerated view. The general availability and variety of wood, its lightness and ease of fabrication by simple tools, at small plants, and on the farm, and the many purposes it serves will continue its use on a very substantial scale. Its use for certain purposes may decline but others will come up requiring the use of wood. The versatility of wood is a major point in its favour as a raw material. It can be converted into paper, fibre, food, clothing, building and numerous other necessities. This makes it an outstanding raw material to keep in reserve for emergencies. An added advantage of wood as a raw material is that when stored on the stump under proper management, it continues to increase in volume for many years.

Forest Products Laboratory, Melbourne, a division of the Australian, C.S.I.R. has applied itself in the above directions, in finding new indigenous woods as substitutes for the imported woods, and new uses of the indigenous timbers. It consequently deals with problems related to the revision of specifications and endeavours to apply to the best advantage the data accumulated on the properties, uses and availability of Australian timbers, with the result that many indigenous timbers have replaced the previously imported ones. For example, to-day Australian battery separator manufacturers are using hoop pine and N. Queensland Kauri in lieu of Port Oxford cedar. Similarly hoop pine, radiata pine and mountain ash are used for match splints in place of poplar; spotted gum for tool handles ; and coachwood for rifle furniture in place of walunt. Queensland maple is being used for airscrews ; also hoop pine, silver ash and silver silk wood as substitutes for the imported air craft spruce.

New data on the properties and service values of a wide range of Australian timbers have been accumulated and a number of prejudices overcome, which has insured the marketing of such timbers to be continued in the future. The years of satisfactory life, which it is expected will be given by some species formerly little used, may also results in their permanency in many fields of use.

The further extension of good seasoning practice, the boric acid treatment of lyctus susceptible species, the adoption of laminating practices, the experience built up of designing and constructing frame structures with ring connectors and the prefabrication of certain types of buildings, should all help to ensure the acceptance of wood as an essential material. The range and uses of resin bonded plywood have extended considerably, and their revolutionary application during wartime has resulted in wider use of this material, than before the war.

Forest Industries

The writer visited Messrs. Furness, Co., factory in Adelaide, where 'Caravan' bodies are manufactured. Here they were converting radiata pine scantlings into 6 in. $\times$ 1 in. planks which when fused together with casein into a pile $1\frac{1}{2}$ ft. thick, and then cut cross wise to give a plank 18 in. $\times$ 1 in., produced strong,

attractive boards when veneered with proper timbers. They were also making 40 ft. beams by a similar process, by gluing thinner pieces. In one of the plywood factories in Adelaide 'Serayah' (Shorea spp.) logs obtained from Borneo were being peeled. These 36" diameter logs, were straight as a ruler, and when peeled gave a faultness veneer of pale yellow colour and good appearance.

The writer also visited a saw-mill, at Mt. Gambier located at Nangwaree in the centre of Pinus radiata plantations. This is a Government Saw-mill working on radiata thinnings of 19 to 24 years of age. The diameter of the logs varied between 6 to 14 inches. The logs received at the mill were 18 to 20 ft. long and before cutting were being sorted for their straightness and thickness. As a normal practice, the best ones are cut into boards 1 in. thick, seasoned, steamed to recover collapse or twist, and planed for use as building or floor boards. The crooked logs are cut into suitable lengths and converted into boards $\frac{1}{2}$ in. to $\frac{3}{8}$ in. by $1\frac{1}{2}$ ft. to 3 ft. for dried fruit packing cases. The log ends $1\frac{1}{2}$ ft. or smaller, were being peeled for match sticks. The wood is peeled green without previous preparation of any kind, except debarking. It peels beautifully and is said to give splints even stronger than those obtained from poplar.

All waste is collected and burnt to raise steam for electricity. After meeting what is required for the electricity there is still 10 tons of waste chips left over per day. It is proposed to instal a wood pulping mill.

Another mill known as "Cellulose (Australian) Pty., Ltd." is located at Snuggery some 40 miles north of Mt. Gambier, within a Pinus radiata plantation. This mill was put up during the war, in 1940, with a capital of half a million Australian pounds, the Government owing a considerable proportion of the share capital. This mill felt considerable difficulty in obtaining the machinery from overseas. Consequently, they had to build much of it in Australia and adapt some others to do the job. I was informed that these parts are working well. Australians like Indians, were at one time told by vested interests that they could not manufacture this or produce that. Now that the Australians have got down to the job, they find that there is hardly any product which they cannot manufacture or any machinery which they cannot fabricate. The remarkable point is that all this is being done by people who have had no special training for the job but were equipped with good common sense and were willing to apply themselves to the job. Mr. Smythe, the manager of the Cellulose Mills is an example of this type of men. He is, by training, a power plant engineer and had never been in a paper mill before.

This mill produces card-boards of many kinds and descriptions, in various ply, using mechanical pulp for the core and chemical pulp for the outside. The roll is 90 inches wide running at a speed of 20 ft. a minute.

One of the major projects of this division of Wood Utilization in New South Wales is to encourage the practice of cutting small dimension materials, in country saw-mills. Efforts are being made to encourage possible users of materials to place orders for the exact sizes they require, and the saw-mills to cut the material in such sizes. It is considered that the cutting of small dimension materials coupled with a preservative treatment, will avoid a considerable amount of waste in the form of sapwood cut from hardwood and poor quality brushwood.

The Forest Products Laboratory at Melbourne, contributed considerably towards the establishment of these industries in the forests. As a result, industries based on the following materials have sprung up :—Veneer and plywood, matches, paper, paper boards, wall boards, cooperage requisites, brushware, turnery, sports goods, etc. Forest Products Laboratory which has 9 sections—wood structure, chemistry, timber physics, timber mechanics, seasoning, preservation, veneer and glueing, utilization and statistics, spends £80,000 p.a. and has a total staff of 200. Research sections are backed with well equipped engineering, instrument making and wood workshops which are devoted to the maintenance of equipment and the manufacture of new equipment designed within the laboratory.

MINOR FOREST PRODUCTS

The principal Minor Forest Products of Australia are :—Eucalyptus oil, sandal wood and oil, tan bark and tan extracts, charcoal, and products of wood distillation. These have led to the establishment of several

industries and are contributing substantially to forest revenues.

Essential oils are produced from the foliage of certain species of Eucalyptus, Melaleuca, and Leptospermum. The entire genus Ecualyptus numbering some 200 species is rich in essential oils but from the commercial point of view only a few varieties are important, either because the quantity of the oil is exceptionally high or that a certain constituent of the oil has a specific commercial value. For example, the oil from *E. Australiana*, *E. Cneorifolia*, *E. dives*, and *E. polybractea* is distilled for use of medicine because of the high content of Cineol; that from *E. citriodora* and *E. macarthuri* is employed in perfumery because of the high content of citronellol or geranyl acetate. Those that are rich in piperitone content, such as that from *E. amygdalina* or *E. dives*, are used for the production of synthetic peppermint or thymol. The eucalyptus oil from *E. amygdalina* and *E. dives* is distilled in New South Wales and brought to Perth, a distance of 2,000 miles, by Messrs. Plaimar, for conversion into peppermint and thymol.

The writer visited Plaimar factory in Perth. Here amongst the many perfumery oils which are distilled, either from the imported raw materials or indigenous, the more important is the sandal wood oil which has almost ousted the Indian sandal oil from its use in medicine. Australian oil is richer in the santalol content (95–96%), and, therefore, the British and French Pharmacœpias prefer the oil of Australia origin. There is some satisfaction to know that for perfumery purposes Indian oil still fetches a higher price.

Plaimar distil the sandal oil from the indigenous Australia species *Santalum spicatum* and a little from *S. lanceolatum* which grow in a region, near York, some 40 miles east of Perth. The entire wood yields nearly 2% of the oil or roughly 48 lb. from a ton of wood, as received at the factory. The roots yield 58 lb. per ton. In 1947 oil worth over £. A. 125,000 was distilled and exported. The tree grows well in Western Australia and unlike our sandal does not suffer from the spike disease. Plaimar also distil citrus oil of all kinds, as well as natural peppermint oil from the home grown *Mentha piperita* which is said to have better flavour than the synthetic oil.

Wattle bark, the famous tanning material, which is a native of Australia has made no headway in that country. The cost of collection of the bark is said to be high, because of the shortage of labour, and therefore unremunerative. Yet Australia is not without tanning materials. They not only satisfy their own needs but have a considerable export trade in tan bark extracts. For this purpose they employ the wood and bark of *Eucalyptus redunca*. The wood of this tree has 17 per cent tans and 20% non tans; poorer than our babul (*Acacia arabica*). The concentrate which is solid, has 18% moisture, 60% tans, 20% non tans and 2% insolubles. It would appear as if some non-tans get fermented during the extraction and some get precipitated in the settling tank. The tan from the wood is of pyrogallol type and that from the bark catechol type. Industrial Extracts, Ltd., produce 7,000 tons of solid extract under the trade name 'Myrtan' per annum, using 1,000 tons of wood per week, at Belmont. These extracts are used for tanning of leather and fishing nets and also for the purpose of water softening. In 1947, extract worth £. A. 110,000 was exported. This industry is valuable adjunct to the forestry industry. To make use of the spent bark, a kraft paper mill is being erected.

The writer visited a wood distillation plant at Wundowie, a distance of 40 miles from Perth. The main consideration at this plant is the production of charcoal which is required for the smelting of pig iron, located in another part of this factory. The factory is Government financed and run, the primary object of the Department of Industries, who put up the plant, being to demonstrate the fact that wood which has otherwise no timber value, in Australia, could be profitably utilized. Charcoal is made by the old American method of heating the wood, in cylindrical ovens, using blast furnace gases and wood gases for the initial heating. The gases produced during the distillation are collected, cooled and the liquid condensates recovered. These are pumped into another part of the factory, for the extraction of acetic acid and methyl alcohol. Tar is separated from the pyroligneous liquors by gravity, and its final traces removed by solvent extraction, using ethyl acetate. The solvent is recovered and the tar burnt to feed the furnace. The furnace

heat is utilized in predrying of wood before distillation.

The clarified pyroligneous liquor is pumped up a distilling column and released at about 2/3rd the height of the tower, so that the methyl alcohol distils off and the aqueous acetic acid flows down the column. Methanol is further rectified and purified in another set of distilling columns. The dilute acetic acid is concentrated by extraction with ethyl acetate. On recovery of the solvent, acetic acid of 90% strength is obtained. The acetic acid so recovered has small proportions of formic and butyric acid in it. These are removed by oxidizing them with permanganate. On distillation, glacial acetic acid is recovered. In this way 220,000 gallons of methyl alcohol and 500 tons of acetic acid are manufatured annually, using 60 cords of cut wood and 60 cords of reject wood, a day. The tar is burnt at present, but there is a proposal to start using it as a raw material for synthetic tans, making use of the phenols present in it. Blue print of the acetic acid plant is available with the writer.

In Western Australia there are no less than 88 saw-mills employing 2,544 men producing 108 million super feet of sawn timber per year. Of this, over 42 million are used for sleepers, boards, boxes, cases, etc. The exploitation of this wealth has given rise to two important industries—mining and timber milling. All over Australia wooden poles are almost exclusively used for telegraph, telephone, and electricity.

FORESTRY EDUCATION

Considerable attention has been devoted in recent years, to the forestry position both by the Commonwealth and the State authorities. The State forests are managed by the State Forestry Departments or Commissions, the functions of which include the preservation and protection of forests, introduction of measures for scientific control and management, conservation marketing, economic utilization of forest produce, and establishment of coniferous forests to remedy the softwood deficiency.

Except for Victoria, the other States do not have Forestry Schools for the training of professional staff. They get their candidates trained at the Australian Forestry School, which is run by the Commonwealth Government. This school is a part of the Commonwealth Forestry Bureau one of whose functions is to provide educational facilities for the training of professional foresters. Training at the School is provided free of charge to students selected and nominated by the States as well as by the Commonwealth.

The Australian Forestry School, at Canberra, has hitherto been turning out some 6 foresters a year, though they think the number will now rise to 20. Even though the courses of study are elaborate, not all are taught because of the lack of teachers. The Victorial School of Forestry runs its own courses.

Like at Dehra Dun, the candidates are selected by the respective States and sent to the forestry school for professional training at government expense.

"Diploma of Forestry of the Commonwealth School is awarded to students who have been accepted as students proceeding to the Diploma and who have satisfactorily completed the full course of two years together with the prescribed fieldwork.

Students who have passed the approved two years' preliminary science course at the University of Adelaide, Melbourne, Sydney, West Australia and Queensland and the full course at the Australian Forestry School, may be granted degree of B.Sc. in Forestry by the University in which they passed the preliminary course. The University of Tasmania awards the degree of Bachelor of Forestry under similar conditions".

In Queenland the following rules apply :—

> "On completion of the 3 years' course at the school and having granted field experience in the service of the Forest Commission for at least one year, selected graduates will proceed direct to a further 2 years' scientific training at Melbourne University, which will enable them to graduate with the degree of B.Sc. in Forestry".

In the Australian Forestry School the minimum educational qualifications for enrolment is matriculation, while in the Queensland Forestry School is "Leaving Certificate". "Other things being equal, those who have qualified for matriculation will receive preference".

SELECTION OF TEACHERS

There is a dearth of suitable teachers in forestry subjects consequently the forestry schools have to think of a long time ahead. Whenever they find in their classes an exceptionally good boy he is marked out for a carrer as teacher or researcher, and trained accordingly. His education is completed by making him spend at least 2 years at a University specializing in his subject. In some cases, it is rounded off by sending him for a year to foreign Universities or research centres. Such a person is appointed permanently to the Australian Forestry School, and released from his service from the State whose nominee he originally was.

The standards of the Australian Forestry School are safeguarded by a Board of High Forestry Education, consisting of 13 members representing the Commonwealth Government, the State Forestry Departments and the Universities of the various States.

TREE PLANTING WEEK
(*Vana Mahotsava*)

BY M. D. CHATURVEDI, I.F.S.
(*Inspector-General of Forests*)

While India has celebrated a tree-planting week for the last 3 years, it was left to the genius of Shri K. M. Munshi, Minister of Food, Forest and Agriculture to galvanize the movement by edifying it to the status of a National Festival. The first week of July, which generally synchronizes with the break of monsoon in the country, was fixed for the purpose, for all time.

2. Conceived brilliantly, the *Vana Mahotsava* brought into bold relief the sacred significance of our forests which once covered the land and cradled the Aryan civilization providing a veritable haven for its saints and sages. In the course of ages, the primeval forest succumbed to the pressure of an ever-increasing population and receded to inaccessible tracts where adverse climatic conditions rendered human habitation impossible. Nowhere are the ravages of man, his cow and plough, so apparent as they are in the tree-lands of the fertile alluvial plains of Hindustan, where the stage has been reached, which compels the cultivator to burn his cowdung manure for lack of an alternative fuel. Ill-planned rural economy, resulting in the thoughtless extension of cultivation, engulfing grazing grounds, village habitations, tree-lands and communication, has recoiled on itself by the operation of the Law of Diminishing Returns. The low, if not diminishing, returns per acre find an easy escape in further extension of agriculture establishing a vicious circle out of which there is no escape. The value of forests in the general economy of our country, their significance in the control of erosion and in the mitigation of devastating floods, and their importance in providing shade and shelter against an oppressive tropical sun and desiccating winds, require more wide-spread recognition than has been hitherto accorded.

3. Civilizations in the past have come to grief and disappeared not by what others did to them, but by what they did to themselves. In Babylon, Egypt, and elsewhere, we have the spectacle of how proud and powerful empires lost their supremacy and vanished under the stress, not of a foreign foe, but of the reckless destruction of their tree-growth and consequent loss of the soil which supported human life. Nearer home, similar trends are already discernible in the spread of the Rajputana desert gnawing into the very heart of India.

4. It was to arouse consciousness among the masses regarding the value of trees and instil in them an adoration for these silent sentinels mounting guard on mother earth that this National festival was conceived. A country-wide drive for planting trees was organized in which every one from the President of the Indian Republic down to the humble peasant took part.

5. In a personal message to Shri Munshi, while accepting his invitation to plant the first tree at Rajghat—the spot hallowed by the sacred memory of Mahatma Gandhi, the President of the Indian Republic observed ; "Our thickly wooded forests were at one time a pride and envy of our land ; not only did they provide an ideal sanctuary to seekers after Truth, but, being instrumental in ensuring ample and timely rainfall, they made a mighty contribution to our agricultural prosperity". It was at Rajghat (Delhi) that the President, the Prime Minister and members of the Cabinet planted a tree each to mark the inauguration of the week on July 1, 1950. Members of the Diplomatic corps representing various foreign countries and other distinguished citizens of Delhi also identified themselves with this ceremony, and every one planted a tree. This was not all. Money poured in for raising trees at this place of national pilgrimage from the rich and poor alike.

6. The movement generated a tremendous enthusiasm throughout the Union. In the Deshbandhu Park at Calcutta, His Excellency the Governor planted a *Bakul* (*Mimusops elengi*) to the accompaniment of songs sung by maidens and hymns chanted by a bard from Shantiniketan of Tagore fame. A descendent of the Bo tree (*Ficus religiosa*), under which Buddha attained Nirvana (Self realization) 2,500 years ago, was planted by the Chief

Minister of West Bengal at Gandhi Ghat on the bank of the Hooghly.

7. While planting fruit trees at his official residence at Naini Tal, the Chief Minister of Uttar Pradesh declared, "considerable damage has been caused to the economy of the State by our indiscriminate destruction of trees. In older days cutting of trees was looked upon with disfavour while planting of new trees was regarded as a meritorious act. Importance of forests and trees for a balanced economy and national self-sufficiency cannot be over-emphasized especially in a predominantly agricultural country like ours".

8. In Bihar, the campaign was launched by His Execellency the Governor who not only planted a fruit tree at the Kanki agricultural farm himself, but also distributed 500 trees among women who had hailed from the surrounding villages to witness the ceremony.

9. In Madras, boys and girls sang a song composed specially for the occasion. The School of Arts, Bombay designed telling posters depicting the significance of trees in the life of the Nation.

10. In the Madhya Pradesh, the Governor planted a tree at the Government House. In the Punjab, the Chief Minister commenced the celebration of the week by planting an Acacia at the Circuit House, Ambala. In Assam, His Excellency the Governor planted a tree at the Lady Hydari Park at Shillong; and he declared the 1st of July as a public holiday for all educational institutions. In Bombay, ceremonial planting was done in several places in the State by the Governor and the Ministers.

11. In a message to the Indian Army, the Commander-in-Chief called for special effort towards planting trees in Cantonments and other Military grounds.

12. By planting trees at Rajghat, dedicated to the Father of the Nation; Kanchipuram, temples of Shiva and Vishnu; Dehotsarga, sanctified by the memory of Lord Krishna; and Nizamuddin, the sacred tomb of a Muslim saint; the Hon'ble Minister of Food, Forest and Agriculture imparted a sacred import to the movement, firing the imagination of the populace. Addressing the citizens of Delhi, Shri Munshi said: "Scientists will tell you that man cannot exist on earth, but for the green glory of the forest. But, the race of man has been committing collective suicide, for they are the worst enemies of trees, cutting and burning greedily and recklessly. In our country, we have turned forests into deserts and we are facing famine to-day". At Madras, the Hon'ble Minister of Forests laid particular stress on planting roadside avenues and urged upon his audience never to fell a tree until two had been planted to take its place. He emphasized the need of legislation for securing for every town in the realm a complement of trees in parks and open spaces, along road and river-sides. Speaking at the Public School at Andheri (Bombay), he elaborated on the culture of India having been interwoven with bountiful nature as symbolized in 'Tulsi Puja'* in Hindu homes, and cited reference to Lord Krishna as 'Kunj Vihari'† in devotional literature. Lord Krishna, he said at Dehotsarga, sought eternal rest under the shade of a tree.

13. The efforts of Shri Munshi bore fruit in an unprecedented response from all and sundry. The entire country-side rose to a man in the celebration of the festival. The peasant planted a tree in front of his humble hut, the cultivator in his field and every one in the village common. School children delighted in fostering plants in their compounds. Trees were planted near wells, graveyards and waste lands. In Bombay, College boys went to an area set apart for the purpose and every one planted a tree. Citizens lent their support to the movement by planting shade and fruit trees in the compounds of their bungalows. Government Departments, Municipalities, and other public bodies organized a concerted drive to utilize every bit of waste land available for the purpose. Trees were put out along roads, canal banks, railways, in courts and camping grounds. The limiting factor was the number of plants available, not the will of the people. The targets set before them by various States comprising the Union total up to a little over 20 million trees. These trees in terms of plantations constitute the equivalent of a forest of a hundred thousand acres with plants put out 15 ft. apart.

14. The after-care of trees so planted constitutes an important plank of the tree-

* Worship of *Ocimum sanctum*.

† Grove—reveller.

planting programme. Recognition of the need of affording adequate protection to plants put out in response to the appeal of the Minister-in-charge of Forests, has taken the shape of the award of prizes for those who have to their credit the highest percentage of survivals.

15. With a view to direct the overwhelming enthusiasm aroused throughout the country along permanently fruitful channels and to stimulate an abiding interest in our forests, Shri Munshi has sponsored the formation of the Vana Premi Sangh—an All-India Forestry Association under the distinguished patronage of the President of the Indian Republic. The Association will forge a common bond between all lovers of trees and woods, private owners of forests, and professional foresters. It will ensure an identity of outlook and instil an *esprit de corps* among those engaged in the raising of trees and their upkeep.

NOTIFICATION

HARA SINGH PURI MEMORIAL PRIZE

Dr. G. S. Puri, Ecologist, Forest Research Institute has offered a prize of Rs. 50 in books to be known as "Hara Singh Puri Memorial Prize" for the best Essay on Forest Ecology. The subject of the essay for this year is "The Edaphic Factor in Forest Ecology". Students of all the Forest Colleges in India may compete. The closing date for the receipt of entries is 15th October 1950. For further particular please write to

Dr. G. S. Puri,
Ecologist,
Forest Research Institute,
New Forest P.O.,
Dehra Dun.

TOUR NOTES SURGUJA DIVISION

BY SHRI G. G. TAKLE, I.F.S.
(*Chief Conservator of Forests, Vindhya Pradesh*)

SUMMARY

The problems which appeared before the Forest Department in organizing the forests of the recently merged States of Chhatisgarh into Central Provinces and Berar (now Madhya Pradesh) and how they were attempted to be solved in the light of the principles of 'Rational Land Management' have been elaborated for the Surguja Division.

I toured the forests of Surguja from the 6th to the 10th April 1948. This was too brief a period to see the forests in any detail but was long enough to show clearly what enormous work confronts a person who wants to install forest organization on the firm basis of rational land management. We are luckily in a position to start work practically on a clean slate, and if we do not want to expose ourselves to the charge of being impervious to lessons from history we should spare no efforts to see that the mistakes committed by us in the past in the management of Central Provinces and other Indian forests are not allowed to occur here.

2. The area of the Surguja State is 6,067 square miles of which 1,768 square miles are reserved forests and 1,944 square miles are unclassed forests. Unlike the forest areas in the C.P., it may be mentioned that all the forest areas and, for the matter of that, all areas situated in these States belong to the State. The total revenue in 1946–47 was Rs. 17,03,245 out of which Rs. 4,21,012 were contributed by forests. The population is estimated to be 5,51,752 persons. These figures work to a density of population of 90·9 per square mile with a revenue of Rs. 3 per person and Rs. 281 per square mile.

3. There are three main types of forests found in this State, viz., Sal forests, mixed forest with a fair proportion of Sal and mixed forests without any Sal. In addition a few stray teak trees are noticed but they are best ignored. Bamboos are also found abundantly and more so in non-sal areas. In addition to these broad types *palas*, *khair*, *tendu*, *kuloo* and *harra* trees occur in large numbers and contribute substantially to the State minor forest produce in the shape of lac, *katha*, *tendu* leaves and myrabolams. Generally speaking the forests are potentially of good quality but their present condition is far from good on account of previous shifting cultivation, uncontrolled fires, indiscriminate grazing, wasteful methods of forest exploitation such as cutting of thousands of sal saplings for fencing a small miserable field. I shall not enter into any more details regarding the silvicultural aspect at this stage nor have I seen the areas in sufficient detail. I have referred to the above broad classification to serve as a guiding basis for rational land management which I propose to discuss below. It is sufficient to say that Surguja forests clearly corroborate the views of a well-known forester (W. C. Lowdermilk—Department of Forestry—U.S.A.).

> "That where man has lived longest in organized societies there the land is in worst condition. This is true of farm lands, grass lands and forest lands though forest lands seem to be the first to be damaged and misused".

4. From the point of view of rational land management the total area of 6,067 square miles of Surguja State will have to be divided on the following basis :—

(i) *Agricultural land*
- (*a*) Cultivation and current fallow,
- (*b*) Waste land—culturable area and uncultivated land.

(ii) *Land under village sites, tanks, roads, Industrial concerns, etc.*

(iii) *Land under forests*

A class
- (*a*) Protective,
- (*b*) Commercial.

B class
- (*a*) Suitable for agricultural use when demand arises,

(*b*) Suitable for nistar purposes, i.e., 'C' class.

C class

Required for nistar in the present circumstances.

5. *Agricultural Land* :—The population of Surguja giving an incidence 90·9 persons per square mile. Corresponds nearest to Chanda district in C.P. which has an area of 9,312 square miles with a population of 8,73,284 persons (94 per square mile). The districts in C.P. which adjoin Surguja, viz., Bilaspur, Raipur, Drug are very much more densely populated. The figures below show the area, population, culturable area, etc., waste lands, forest area of these districts and can guide us to decide the area that will be appropriate for Surguja :—

	Total area square miles	Population	Incidence	Agricultural land square miles		Forests	
				Culturable	Fallow	Government	Private
1. Bilaspur ..	7,538	15,49,509	206	3,055	781	544	2,788
2. Raipur ..	8,283	15,16,686	183	3,458	952	1,296	1,957
3 Drug	4,716	9,28,851	197	2,624	207	186	1,020
4. Chanda ..	9,312	8,73,284	94	1,829	498	2,486	3,866

This gives an average area under cultivation per person of population as follows :—

Bilaspur .. 1·3 acres per person.
Raipur .. 1·5 acres per person.
Drug .. 1·7 acres per person.
Chanda .. 1·0 acre per person.

The average of cultivated land per person for the whole of United India works as follows, based on various census figures :—

1901 .. 1·28 acres per person.
1911 .. 1·24 acres per person.
1921 .. 1·21 acres per person.
1931 .. 1·08 acres per person.
1941 .. 1·00 acre per person.

Taking all these facts into consideration we should be safe in assuming an area of 1·6 acres under culturable agricultural land and ·4 acre under waste land. Since the present population of Surguja is 5,51,752 persons an area of 8,82,803 acres or 1,380 square miles approximately should be classified as land under cultivation and another 345 square miles as culturable fallow land, etc. The total under agricultural land should thus be 1,725 square miles or 11,03,500 acres approximately if land management is to be guided on rational basis.

I was unable to find out exactly how much land is at present classified under agricultural land including waste land, etc., but if it should be more than 11,03,500 acres any further demand for more land has to be resisted since it will be tantamount to shifting cultivation and be ruinous to the land in the long run.

6. *Land under village sites, etc.*—From the figures given in paragraph 5 above for the four districts of the C.P., it is clear that the following area of land is unaccounted for and is presumably covered by the village sites, tanks, industrial concerns, towns, cities, roads, canals, railways, etc. I am unable to explain why Drug should have such a large unaccounted area ; but do not want to delay the drafting of this note till I have ascertained the reasons for this apparent discrepancy from the Director of Land Records. The areas are :—

Bilaspur .. 365 square miles or 5% approximately.
Raipur .. 620 square miles or 7·5% approximately.
Drug .. 679 square miles or 14·4% approximately.
Chanda .. 633 square miles or 6·8% approximately.

We shall thus be safe in assuming an area of 10% under this classification for Surguja. This will thus work to an area of 600 square miles.

7. *Land under forests.*—I have proposed to divide the land under forests in three classes. 'A' class will comprise land that is proposed

to be maintained as forests for ever. These are further sub-divided into Protective and Commercial. It is commonly accepted now that forest policy must, as a general rule, primarily ensure the perpetuation of sufficient forest to provide for the various requirements of a country and also to guarantee the conservation of the natural wealth of the country—Soil and water. It can never be too strongly emphasized that soil depletion whether caused by chemical exhaustion or physical erosion is the nation's enemy No. 1. "All forests" will be the ideal condition but deviation from this ideal is the price that civilization demands. Dr. Shuhart the world authority on soil erosion has observed in his report "If all the land could remain under forests in which a good forest floor is permitted to exist, where burning is eliminated and where the soil is covered by many generations of leaves forming an absorptive mulch which reduces and retards run off and permits streams to run clear even after heavy rains, there would be no soil and water conservation problem".

8. Forests required to be maintained on protective grounds must therefore have the first preference. Forests on steep hills, along the nala and river banks and also those found in the catchment areas of important rivers must therefore be classified as protective forests. (I am not enamoured very much of this word and would be grateful for suggestions for a more expressive term). Unfortunately my knowledge of geology is very limited and I could not get any reference which dealt with the geological survey of this tract but a cursory examination of the country shows that over a large area of the forests the underlying rock is particularly porous and friable sandstone which yields very dry shallow and sandy soil which is pre-eminently susceptible to sheet erosion during the monsoons and drift erosion in the summer storms. There are signs everywhere that shifting cultivation in one form or the other was generally prevalent in not too distant a past and the same coupled with uncontrolled grazing and devastating annual fires has caused the present degraded condition of the forest vegetation. It is almost apparent that the original forests were far better than the present growth and it may be possible that provided adequate measures are taken the forests that will spring up as a result of the systematic management now proposed will be better than the present over-exploited growth. I expect that 1,300 square miles will have to be so treated as protective forests. This figure has, however, been arrived at by the study of maps and may require some amendment when actual survey takes place.

9. *Commercial forests*.—In a scheme of rational land management the most economic use of land is a consideration that follows after the protective aspect is taken into account. There are several areas of land in the C.P. and Berar which yield a better value to the State as forests than they would have as cultivation. As an example the following figures may be quoted (Forest Revenue Figures for 1946-47—The latest available are taken).

District	Revenue from forests per acre of land under forests		Land revenue per acre of land under agriculture
	Gross	Net	
1	2	3	4
Hoshangabad ..	3–2–9	2–2–4	1–8–2
Amraoti ..	2–9–4	1–13–0	1–12–5
Chhindwara ..	2–3–10	1–12–1	0–12–5
Chanda ..	2–3–0	1–8–7	0–13–2
Nagpur, Wardha ..	2–0–6	1–7–9	1–4–4
Betul ..	1–14–3	1–7–2	0–8–11
Seoni ..	1–12–0	1–5–1	0–13–10
Bhandara ..	1–10–5	1–3–3	1–3–9
Nimar ..	1–4–9	0–15–11	0–13–0

These are the areas, e.g., Allapalli forests, Bori forests, parts of Sironcha and Betul areas where forestry is the best paying land industry. I reckon that approximately 1,200 square miles will be available from Surguja division for such a reservation.

The aggregate area under 'A' class forests is thus likely to be 2,500 square miles.

10. '*B*' *class forests*.—In paragraph 5, I have suggested that an area of 1380 + 345 square miles should be classified as agricultural land. This by no means implies, however, that there will be no more suitable land for cultivation in Surguja division. The limit of 1,725 square miles was proposed to be

imposed after taking into account the present density of population. Some more area between 700 to 800 square miles, is likely to be available for cultivation if and when the population increases, after satisfying fully the forest and other needs of the locality from the point of view of rational land management. This area will be classified as 'B' class forests which will be held in trust by the Forest Department for management till such time as a genuine demand for the same arises. Spurious demands will have to be steadfastly withstood. Assuming such an area to be 800 square miles 200 square miles out of it will have to be set apart as fuel, fodder and nistar reserves for these villages and the remaining 600 square miles would be available to maintain an additional population of 2,40,000 persons in Surguja calculating an incidence of 1·6 acres of agricultural land per person. If, however, the All-India average of 1·0 acre per person is to be applied the Surguja division may be able to feed a population of $(1380+600) \times 640 = 12{,}67{,}200$ or an addition of approximately 7,00,000 persons to the present figure. Out of these 800 square miles of 'B' class forests 600 square miles will be classified as B(*a*) and 200 square miles as B(*b*).

11. '*C*' *class forests*.—Forests which are designed to meet the agricultural requirements of the population should be included in this category. Forests really required for nistar purposes from the enormous areas now included as "Katat" forests in Surguja should be included in this class and the balance should either be transferred to B(*a*) or B(*b*) class or 'A' class forests, depending on the nature of the forests, the terrain in which it is grown, etc. We in the Central Provinces and Berar have now realized the importance of these nistari forests as fuel and fodder reserves and schemes are advocated to create such forests in parts of Berar and Chhatisgarh where no forests are to be encountered for miles and miles of country. In this connection I need not offer any excuses for reproducing the following paragraph from Mr. Hamilton's note on Gwalior forests since it is so very relevant to our subject matter. He says "If possible, earmark definite areas for the supply of firewood to meet urban requirements. Their requirements are great, they can afford to pay for them ; firewood reserves must be established, even if land has to be acquired and it must be assumed that the plantations will be made to pay through sales. As long as towns people offer high prices for firewood so long will the cultivator prefer to sell what little firewood comes into his hands rather than use it to save cowdung to manure his fields. For the villages the problem is more difficult and the firewood must be made available free or at nominal cost. All waste land must be utilized and if co-operation can not be obtained through persuasion, action will have to be taken through a simple land utilization Act, such as several administrations now favour. It is better, however, to work with the consent of the people, if it can be obtained, through co-operative societies and panchayats".

12. We must not permit the same mistakes to be perpetuated in these areas though I fear that cultivation has made heavy inroads already in some areas, e.g., the areas lying on the Ambikapur–Lakhanpur road. I am unable to say exactly what proportion of the total land under agriculture will constitute an ideal for nistar purposes. It looks to me that approximately 25% of the area under cultivation should serve for this purpose. This should, as far as possible, be situated in the midst of a group of villages and may be run on the lines of panchayat forests as is being done in 'Ulnar' forest area near Jagdalpur in Bastar. We can thus expect that approximately 450 to 500 square miles will be classified as 'C' class forests. I would like to emphasize that 'C' class forests must be regarded with the same feeling of sanctity as the 'A' class forests and no encroachments on the same by agriculture should be permitted under any pretext whatever.

13. To sum up the distribution of land in Surguja division, as I envisage it on the basis of rational land management will be :—

(*a*) Agricultural land ..	1,380	square	miles
(*b*) Fallow land	345	,,	,,
(*c*) Nistar forests	450	,,	,,
(*d*) Village sites, etc.	600	,,	,,
(*e*) B class forest land for future agriculture	600	,,	,,
(*f*) B class forest land for future 'C' class forests ..	200	,,	,,
(*g*) Protective Forests ..	1,300	,,	,,
(*h*) Commercial forests ..	1,192	,,	,,
	6,067	,,	,,

The total area under all classes of forests will thus be a little over 50% in the final

analysis. This figure is 44·3 for Bilaspur, 39·7 for Raipur, 24·9 for Drug and 69·0 for Chanda.

14. As I have mentioned previously the whole of the forest area of the State belongs to the Forest Department and there are no intermediary proprietors such as malguzars or Zamindars, etc. Even the Kharposdars seem to have limited rights which could be terminated at the will of the Ruler. These have been actually so terminated during the last three or four years in the adjoining State of Korea. This full ownership throws very great responsibility on the State and no areas from forests should be lightly handed over without a full enquiry, either in the so-called reclamation cases or for grow more food compaign. In paragraph 5, I have denoted what should constitute the optimum area under agriculture in this division in the present state of advancement and this area should be reached after proper enquiry. I hold rather strong views on the question of grow more food compaign. The intensification of agriculture which depends on seven factors, viz. (1) good cultivation, (2) seed, (3) irrigation, (4) manure, (5) drainage, (6) bunding and terracing and (7) crop management, should be our main aim and not mere extension of area. It is notorious that our province produces the least crop out-turn per acre except in the case of cotton and juar, of all the provinces in India which in her turn produces the lowest when compared to other advanced countries of the world. Thus we in C.P. produce on an avarage 655 lb. of rice per acre as against 967 in Bombay, 921 in Bengal and 1048 in Madras or nearly 3000 lb. in China, Japan and Italy. The story about wheat is the same. The real movement for grow more food should be in the direction of the seven fundamentals suggested above instead of handing over more and more areas for the so-called cultivation which in the final analysis is little different to or better than shifting cultivation. In the C.P. private owners of forests have taken advantage of the grow more food compaign to ruin their forests and produce more charcoal and in Berar this has resulted in the devastation of several 'C' class forests of which there was keen scarcity already. Superficially more areas under cultivation seems to be the ready answer to the grow more food compaign but on a careful analysis this is seldom, if ever, found to yield the expected results. Areas should, therefore, be handed over for more cultivation only as a result of very careful spot enquiry and no slogans should stampede us in an action which may have to be subsequently repented.

15. Bowar cultivation has been luckily stopped in all the ranges during the last few years by orders of the Maharaja Saheb. The few exceptions were in the case of Korbas who are the most backward people in this tract. This year attempts were made to revive the system in Lakhanpur areas. This must be discouraged. There are some Korbas who practice shifting cultivation here in the same way as the Madias do in Bastar. These are luckily confined to Kusmi range and Mainpat block in Sitapur range. It may mean real hardship to these *adivasis* if this method of cultivation to which they are used from times immemorial is discontinued all at once. As a first step, however, towards the abolition of this pernicious and destructive method of cultivation these operations should be confined to a limited area as is being done in the Baiga chak in Mandla. Intense propaganda will have to be carried on side by side so that these people may in course of time, say fifteen years, be won over to a more settled method of cultivation.

16. It is merely a truism to say that ultimately a working plan providing for the scientific management of these forests with its concomitant grazing prescriptions, etc., will be the most desirable thing. Such a working plan cannot, however, be attempted until the forests have been finally classified and reserved as suggested by me in earlier paragraphs of this note and this may take some time yet. In the meantime, however, arrangements have to be made to :—

(*a*) meet the legitimate requirements of the people particularly when the indiscriminate cutting in *Katat* forests is to be discouraged,

(*b*) meet the commercial needs of the people and thus help the division financially,

(*c*) carry on cultural operations in forests which are so very urgently needed.

Working schemes will have to be prepared for such of the forests as have been demarcated so far where demand exists. Five such work-

ing schemes are already in operation at present and the same work should be extended. Clear felling in these areas may as a general rule be unsuitable mainly on the ground of dangers of erosion and frost. Selection-cum-improvement fellings on a felling cycle of 30 years may be more suitable.

17. In addition to the work of survey and reservation that I have outlined in the earlier paragraphs, one other important work will be to have a proper road scheme and a building programme. Conditions in this division in connection with both the roads and buildings have to be personally seen to be fully realized. There exist some roads which are called Shikar roads. These alignments have a considerable scope for improvement but these roads are the only means of communication now and should be maintained. A road scheme has to be drawn up bearing in mind the alignment of the railway line under construction. Suitable quarters for the staff and accommodation for touring Officers are also essential for improvement in the standards of efficiency.

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART II

(*Continued from the* "Indian Forester", *August 1950, page 342*)

Design for a timber bridge of span 20 feet, width 10 feet to take I.R.C. 'B' class loading, timber used being sal (*Shorea robusta*). Grade of timber being structural No. 2 conforming to standard grade.

Design of Decking :—See Fig. 11.

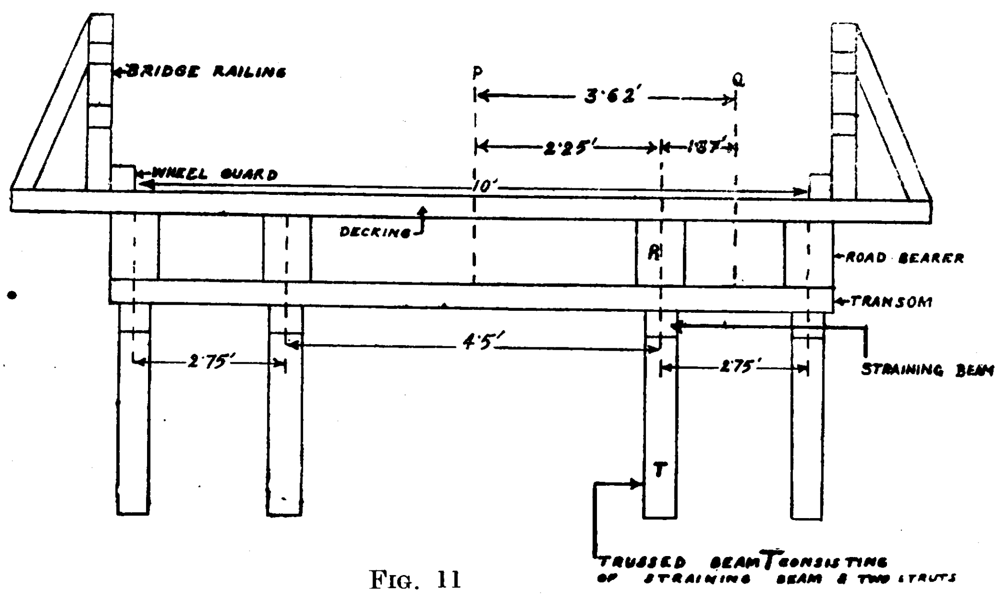


FIG. 11

(1) Assume width of decking 12 inches.

(2) U.D.D.L. due to 0·34 ton per linear foot of each traffic lane of bridge **on 4′–6″** span of decking is (ref. specification A of I.R.C. mentioned in previous **design** of 15 feet span bridge)

$$W_1 = \frac{0\cdot34 \times 2240}{10} \times \frac{4\cdot5}{1} = 343 \text{ lb.}$$

(3) Dead weight of decking itself of 4′–6″ length, 12″ wide and say 4″ thick is

$$W_2 = \frac{4\cdot5}{1} \times \frac{1}{3} \times \frac{60}{1} = 90 \text{ lb.}$$

Considering prolong duration of dead loads for computing B.M. we have

$$W_2 = 2 \times 90 = 180 \text{ lb.}$$

(4) $\therefore$ $W_1 + W_2 = 343 + 180 = 523$ lb. $= 530$ lb. (say).

(5) B.M. due to (4) is $\frac{WL}{12}$ (due to continuity consideration)

$$\therefore \text{ B.M.}_{max} = \frac{530 \times 4\cdot5 \times 12}{12} = 2385 \text{ in lb.}$$

(6) U.D.D.L. due to 6 tons knife-edge load is

$$W = \frac{6 \times 2240}{10} \times \frac{4 \cdot 5}{1} = 6048 \text{ lb.}$$

(7) $B.M._{max}$ due to (6) $= \frac{WL}{10} = \frac{6048 \times 4 \cdot 5 \times 12}{10}$

$$= 32659 \text{ in lb.}$$

(8) Total max. B.M. $= 2385 + 32659 = 35044$ in lb.

(9) Now B.M. = f z (By simplified theory)

$$\therefore\ 35044 = \frac{2400}{1} \times \frac{bd^2}{6}$$

But b = 12 inches width

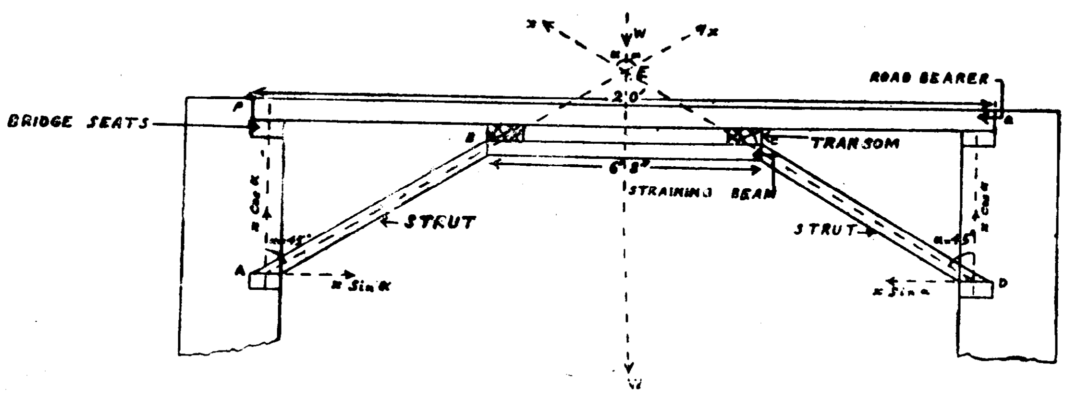
$$\therefore\ d^2 = \frac{35044 \times 6}{2400 \times 12} = 7 \cdot 3 \text{ inches}$$

$$\therefore\ d = 2 \cdot 7 \text{ inches.}$$

Use main decking of 2·75 inches and over it at right angles place planks $1\frac{1}{2}$ inches thick nailed down to main decking to take wear and tear of traffic. The upper $1\frac{1}{2}$ inches planking can be renewed as and when required.

The thickness of decking is safe both against shear and deflection as was shown by calculation in the previous design of decking for a 15 feet span bridge.

Design of Straining beam and Struts :—See Fig. 12.



TRUSSED Beam T

FIG. 12

Note :—(1) Keep angle a not more than 45° if possible. If unavoidable then iron fastenings to be used over and above carpentry joints to connect and secure straining beam to strut.

(2) If roadbearers are placed directly on the straining beam, then the latter will be subjected to a cross breaking stress (i.e., bending stress) due to bending in roadbearers in addition to the direct compressive stress due to its being part of a trussed beam.

To prevent that additional bending in straining beam, transoms are placed at the ends of straining beam to separate direct contact of roadbearers from straining beam (see Fig. 12).

Proportion of load carried by different members of the assembly shown in Fig. 12.

Studying Fig. 12 in conjection with Fig. 13 and Fig. 11 we have

(1) Weight carried by *straining* beam BC of trussed beam 'T' (see Fig. 11) = $\frac{2}{3}$ of the total weight coming over width PQ (Fig. 11) and length MN (Fig. 13) of the bridge.

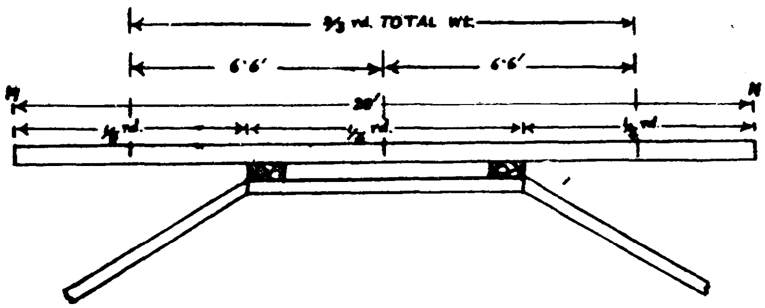


FIG. 13

(2) Weight carried by portion of the abutment between PQ = $\frac{1}{6}$ of the total weight, coming over width PQ and length MN of the bridge (Fig. 11 and Fig. 14).

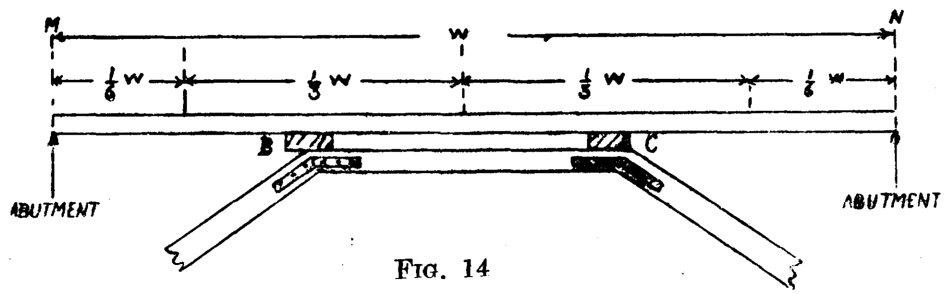


FIG. 14

(3) Load acting through each transom at B and C between PQ = $\frac{1}{3}$ of the total load coming over width PQ and length MN of the bridge. See Fig. 14.

(*a*) *Design of Transom.*—Here transoms carry only a crushing load coming perpendicular to its grain of timber. (See Fig. 15).

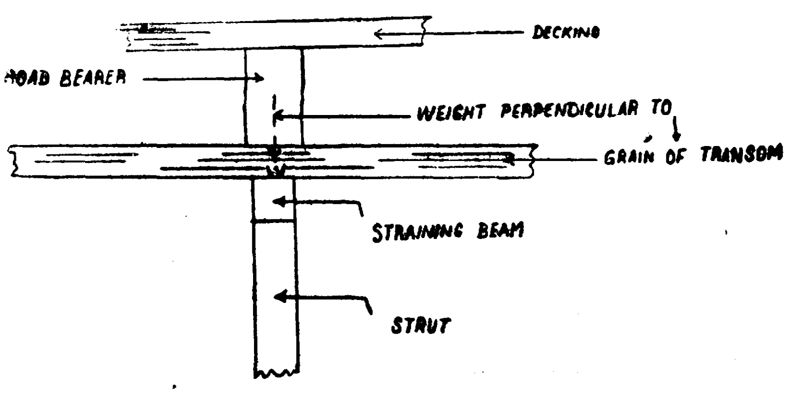


FIG. 15

Allowable compressive stress perpendicular to grain, for sal is 900 lb. per sq. inch.

(1) Load due to 0·34 ton per linear ft. of each traffic lane over each transom between PQ and MN is

$$\frac{0\cdot34 \times 2240}{10} \times \left(\frac{6\cdot6}{1} \times \frac{3\cdot62}{1} \right) \text{ see Figs. 1 and 3}$$
$= 1930$ lb. (approx.).

(2) Load due to 6 tons knife-edge load is
$$\frac{6 \times 2240}{10} \times \frac{3\cdot62}{1} = 4865 \text{ lb.}$$

(3) Dead weight of portion of decking plus one Roadbearer is
$$\left(3\cdot62 \times 6\cdot6 \times \frac{4\cdot25}{12} \times 60 \right) + \left(\frac{10}{12} \times \frac{5}{12} \times \frac{6\cdot6}{1} \times \frac{60}{1} \right)$$
assuming a section of Roadbearer to be $10'' \times 5'' = 508 + 146 = 654$ lb. (approx.).

(4) Total load on portion of transom between PQ is (1) + (2) + (3)
$= 1930 + 4865 + 654$
$W = 7416$ lb. $= 7449$ lb. (say).

(5) $\therefore$ Area of cross section of each transom $= \frac{W}{900} = \frac{7500}{900} = 8\cdot3$ sq. inches.

(6) Use a very safe section of $3'' \times 6''$ so as to provide for sufficient bearing surface of roadbearers' ends over it in case of small lengths of roadbearers being used (see Figs. 16 and 17).

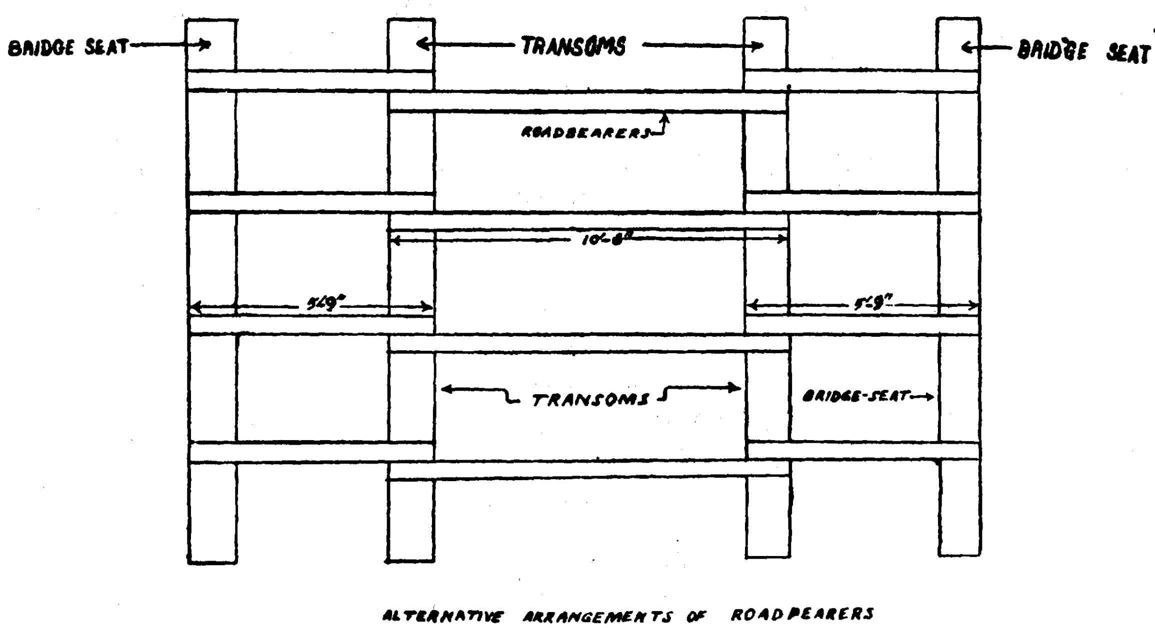


FIG. 16

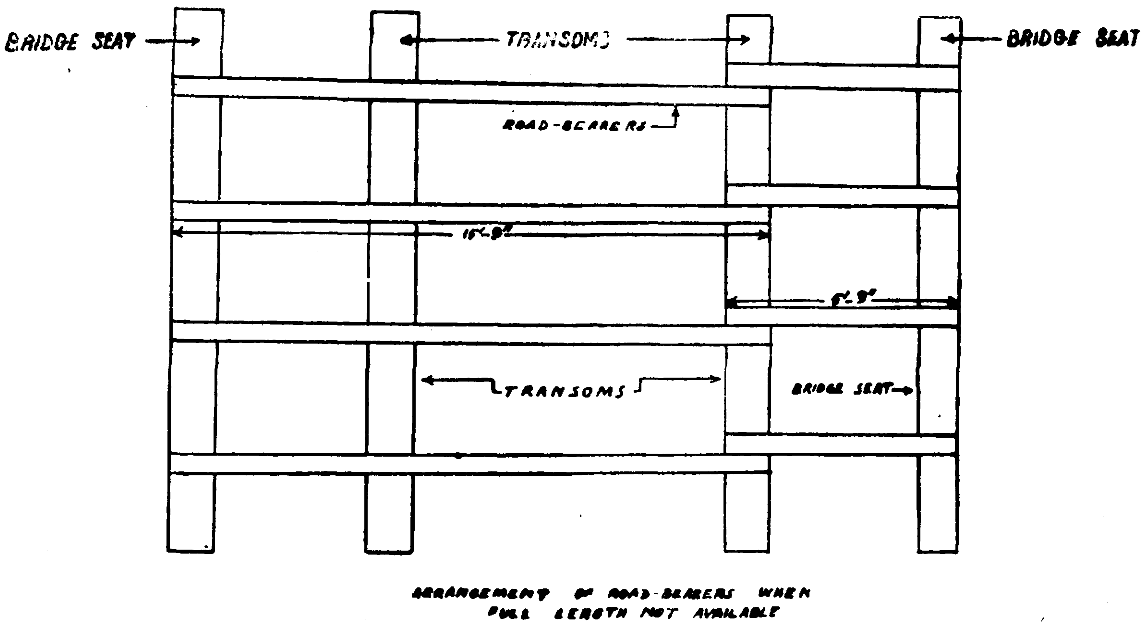


FIG. 17

(*b*) *Design of Straining beam BC* :— (See Fig. 18)

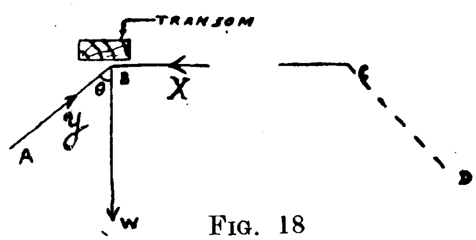


FIG. 18

(1) Load due to U.D.D.L. of 0·34 ton per linear ft. of each traffic lane over BC, between PQ and BC (Figs. 11 and 12) is

$$\frac{0\cdot 34 \times 2240}{10} \times \frac{3\cdot 62}{1} \times \frac{20}{3} = 1886 \text{ lb.}$$

(2) Line load of 6 tons knife-edge load is

$$\frac{6 \times 2240}{10} \times \frac{3\cdot 62}{1} = 4860 \text{ lb. (Fig. 11).}$$

(3) Dead weight of portion of decking plus one Roadbearer = 654 lb. (as calculated previously).

(4) Total weight on point B of straining beam is
$W = 1886 + 4860 + 654 = 7400$ lb.

(5) $\therefore$ Compressive force in straining beam by resolution of forces is (Fig. 18)

From Lami's theorem we get $X = \dfrac{W \sin \theta}{\sin (90 + \theta)} = W \tan \theta = W \tan 45°$

because $\alpha = 45° = \theta$ and $\tan 45° = 1$

$\therefore$ X = 7367 × 1 = 7367 lb. (compressive)

$\therefore$ Straining beam should be designed to take a compression of 7400 lb.

(6) Now length of BC = 7 feet approx.

(7) Try a section 4″ × 4″ for BC

Slenderness ratio $\frac{l}{d} = \frac{7 \times 12}{4} = 21$

Since slenderness ratio 21 is > 15, BC will be designed as long column.

(8) Permissible stress (compressive) for long column is

$P_c = f_c\left(1 - \frac{l}{60d}\right)$......formulæ used by American Railway Engineering Association

$\therefore P_c = 1700\left(1 - \frac{7 \times 12}{60 \times 4}\right)$

$\therefore P_c = 1150$ lb. per sq. in.

(9) Actual stress on BC due to 4″ × 4″ section is $\frac{W}{A} = \frac{7400}{9} = 822$ lb. per sq. in.

where A = net area of section after deducting for joints.

Since actual stress induced is very much less than that permissible stress P_c for long column therefore section 4″ × 4″ is ample after considering actual reduction in section due to cutting and boring for carpentry joints and fastenings.

Note :—It is safe practice to find first the net area $\left(\text{i.e., } A = \frac{W}{P_c} = \frac{7400}{1150} = 6 \cdot 4 \text{ sq.in.}\right)$. To this net area add $\frac{1}{3}$rd net area to allow for reduction in section due to joints and borings $\left(\text{i.e., } 6 \cdot 4 + \frac{6 \cdot 4}{3} = 8 \cdot 53 \text{ sq. inch}\right)$.

Thus we see that even if we take a section of 3″ × 3″ for BC it will suffice

(*c*) *Design of Struts AB and CD*.—(See Fig. 18).

(1) Compressive force in struts AB or CD by resolution of forces is

$$Y = \frac{W \sin 90^\circ}{\sin (90 + \theta)} = W \times \frac{1}{\cos\theta} = W \sec\theta$$

where $\theta = a = 45^\circ$ and $\sec 45^\circ = 1 \cdot 4142$

$\therefore Y = 7400 \times 1 \cdot 4142 = 10465$ lb. (compressive) = W.

(2) Try a section 4″ × 4″

From slenderness ratio again this will give us a long column

$\therefore P_c = 1150$ lb. per sq. in. as before.

(3) $\therefore$ net area $A_n = \frac{W}{900} = \frac{10465}{1150} = 9$ sq. inches.

(4) $\therefore$ Actual area $= A_n + \frac{A_n}{3} = 9 + 3 = 12$ sq. inches.

(5) $\therefore$ Section of 4″ × 4″ is ample for struts AB or CD.

(*d*) *Design of Roadbearers*.—Greatest unsupported span of the roadbearer 'R' carrying max. weight (as in Fig. 11) is 7 feet approx. due to introduction of transoms.

(1) Load on roadbearer due to 0·34 ton per linear foot of each traffic lane is

$$W_1 = 3 \cdot 62 \times 7 \times \frac{0 \cdot 34 \times 2240}{10}$$

$$= 1940 \text{ lb. (approx.).}$$

(2) Dead weight of roadbearer assuming a section of 10″ × 4″ is

$$W_2 = \frac{10}{12} \times \frac{4}{12} \times \frac{7}{1} \times \frac{60}{1} = 117 \text{ lb.}$$

Considering prolong duration of loading

$$W_2 = 2 \times 117 = 240 \text{ lb. (say).}$$

(3) Dead weight of portion of decking over roadbearer of 7 feet is

$$W_3 = 7 \times 3{\cdot}62 \times \frac{4{\cdot}25}{12} \times \frac{60}{1} = 508 \text{ lb.}$$

Considering prolong duration of dead loads :

$$W_3 = 2 \times 508 = 1020 \text{ lb. (say).}$$

(4) Total distributed load on roadbearer 'R' is

$$W_1 + W_2 + W_3 = 1940 + 240 + 1020 = 3200 \text{ lb.}$$

(5) $B.M._{max}$ due to (4) $= \frac{WL}{8}$ (considering distributed load condition and non-continuity of roadbearer due to use of short lengths. (See Figs. 16 and 17).

$$\therefore \; B.M._{max} = \frac{3200 \times 7 \times 12}{8} = 33600 \text{ in lb.}$$

(6) U.D.D.L. due to knife-edge load of 6 tons per traffic lane is

$$W = \frac{6 \times 2240}{10} \times \frac{3{\cdot}62}{1} = 4865 \text{ lb.}$$

(7) $B.M._{max}$ due to (6) at centre of 7 feet span is $\frac{WL}{4}$ (considering concentrated load condition)

$$\therefore \; B.M._{max} = \frac{4865 \times 7 \times 12}{4} = 102165 \text{ in lb.}$$

(8) Total max. B.M. is 33600 + 102165

$$B.M._{max} = 135765 \text{ in lb.}$$

(9) Assuming width of roadbearer to be 4″

then B.M. $= f\,z$

$$\therefore \; 135765 = 2400 \times \frac{bd^2}{6}$$

$$\therefore \; d^2 = \frac{135765 \times 6}{2400 \times 4} = 85$$

$$\therefore \; d = 9{\cdot}2 \text{ inches (approx.)}$$

∴ For strength of roadbearer use a section 10″ × 4″.

Testing of Roadbearers against shear :—

(1) Max. shear on roadbearer due to 0·34 ton per linear foot of each traffic lane is

$$\frac{1}{2}\left(\frac{0{\cdot}34 \times 2240}{10} \times \frac{3{\cdot}62}{1} \times \frac{7}{1}\right) = 970 \text{ lb.}$$

(2) Shear due to 6 tons per traffic lane is when the knife-edge load is at the end of roadbearer

$$\text{i.e., } S_{max} = \frac{6 \times 2240}{10} \times \frac{3{\cdot}62}{1} = 4866 \text{ lb.}$$

(3) Shear due to dead weight of decking and roadbearer

$$S_{max} = \tfrac{1}{2} (433 + 117) = 275 \text{ lb.}$$

(4) Total max. shear = 970 + 4866 + 275 = 6111 lb.

(5) Now average shear $= \frac{\text{Max. shear}}{\text{sectional area}}$.

$$\therefore S_a = \frac{S_{max}}{A}$$

$$= \frac{6111}{10 \times 4} = 153 \text{ lb. per sq. inch.}$$

(6) Max. intensity of shear stress $= \frac{3}{2} s_a$

$$s_m = \frac{3}{2} \times \frac{153}{1} = 230 \text{ lb. per sq. inch.}$$

This actual $s_m >$ the allowable s_m for sal which is 180 lb. per sq. inch.
Hence section of roadbearer fails in shear.

(7) Use a larger section of 10″ × 5″ and test whether this will stand a shear of 6111 lb.

(8) $s_a = \frac{6111}{10 \times 5} = 122$ lb. per sq. inch.

(9) $s_m = \frac{3}{2} s_a = \frac{3}{2} \times \frac{122}{1} = 183$ lb. per sq. inch.

This actual s_m just balances allowable 180 lb. per sq. in. of max. intensity of shear stress for timber sal.

(10) Section of 10″ × 5″ is just safe against shear.

Testing of Roadbearer 'R' against Deflection :—

Actual deflection coming on the roadbearer is

δ_1 due to 0·34 ton per linear foot of each traffic lane

δ_2 due to 6 tons knife-edge load per traffic lane

δ_3 due to three times the dead load due to material of decking and weight of roadbearer itself.

$$(\delta_1 + \delta_3) = \frac{5}{384} \frac{WL^3}{EI} \text{ (equation for distributed load condition)}$$

where $W = 1940 + 3 (430) + 3 (117)$

$W = 3581$ lb.

$L = 7$ feet

$E = 2 \times 10^6$ for sal

$$I = \frac{bd^3}{12} = \frac{5 \times 10^3}{12}$$

$$\therefore \delta_1 + \delta_3 = \frac{5}{384} \times \frac{3581 \times (7 \times 12)^3}{2 \times 10^6 \times \frac{5 \times 10^3}{12}}$$

$$= 0{\cdot}045 \text{ inch.}$$

$$\text{Again } \delta_2 = \frac{1}{48} \frac{WL^3}{EI} \text{ (equation for concentrated load condition)}$$

where $W = 4866$

$$\therefore \delta_2 = \frac{1}{48} \times \frac{4866 \times (7 \times 12)^3}{2 \times 10^6 \times \frac{5 \times 10^3}{12}}$$

$$= 0{\cdot}09 \text{ inch.}$$

Total max. deflection $= \delta_1 + \delta_3 + \delta_2$

$= 0{\cdot}045 + 0{\cdot}09$

$\therefore$ Total actual $\delta = 0{\cdot}135$ inch.

Permissible $\delta = \frac{1}{240}$th of the span.

i.e., permissible $\delta = \frac{1}{240} \times \frac{7 \times 12}{1} = 0{\cdot}35$ inch.

Thus actual $\delta <$ permissible δ

$\therefore$ Section of roadbearer is safe against deflection.

TABLE I

Sal timber required

A complete statement in tabular form of a Bridge 20 feet span, 10 feet traffic width, made of sal *timber of standard structural grade No. 2*

Serial No.	Name of Items	Section b × d	Sectional area per piece	Length per piece		Cu. ft. per piece	Number of pieces required	Total cu. ft.	Cons-tructional remarks	Serial No.
		in. × in.	sq. in.	ft.	in.	Cu. ft.	Nos.	Cu. ft.		
1	Decking of sal sleepers									
	Main Deck	12 × 2·75	33	12	0	2·75	20	55·00	1a, 1b	1
	Wearing Deck	12 × 1½	18	10	0	1·25	20	25·00		
2	Roadbearer or stringers	5 × 10	50	21	0	7·30	4	29·20	2a, Figs 16, 17 and 20	2
3	Bridge seat	6 × 3	18	13	0	1·60	2	3·20	3a, 3b	3
4	Solid strutting or spacers	6 × 4	24	4	0	0·60	4	2·40	4a	4
				2	3	0·38	8	3·04		
5	Transoms	6 × 3	18	13	0	1·60	2	3·20	Fig 21, 5a	5
6	Four Trussed Beams									
	Straining beams	4 × 4	16	7	0	0·80	4	3·20	6a	6
	Struts	4 × 4	16	9	10	1·10	8	8·80		
7	Strut seats	6 × 3	18	13	0	1·60	2	3·20	Fig. 19	7
8	Guard blocks	5 × 3	15	0	6	0·05	12	0·60	Fig. 20 and	8
9	Wheel guard or Ribbonds	5 × 4	20	20	0	2·80	2	5·60	Fig. 11	9
10	Rail posts	5 × 4	20	4	0	0·55	10	5·50	same as that	10
11	Hand Rails	3 × 4	12	20	0	1·66	4	6·64	for bridge 15	11
12	Inclined struts for bracing rail post	3 × 3	9	5	0	0·38	6	2·28	feet span	12

Total cu. ft. of timber required 156·86.

NOTE ON CONSTRUCTIONAL REMARKS FOR

(1*a*) Same as that for 15 feet span bridge Table I remarks 1*a*.

(1*b*) Same as that for 15 feet span bridge Table I remarks 1*b*.

(2*a*) Shorter lengths of roadbearers with overlaps at either of the transoms could be advantageously used (see Figs. 6 and 7). In this case roadbearers should be staggared in order to provide minimum of 6 inches bearing over the transom for each end of roadbearer.

(3*a*) Same as that for 15 feet span bridge, Table I remarks 2*a*.

(3*b*) Same as that for 15 feet span bridge, Table II remarks 2*b*.

(4*a*) Same as that for 15 feet span bridge, Table I remarks.

(5*a*) Place the transoms in such a way that geometrical axis of transom and those of the straining beam and strut pass through a point (see Fig. 11).

(6*a*) Struts transmit the thrust obliquely to the abutments. This force when resolved horizontally and vertically give X sin α horizontal force and X Cos α vertical force. See Fig. 2.

(i) X Cos α gives a crushing load on abutments for which it should be designed.

(ii) X sin α gives a horizontal force trying to shear or push the abutment sideways. The abutment must, therefore, be strong against crushing for (i) and shearing for (ii).

TABLE II

Hardware required for 20 feet span bridge of Trussed Beam type

Serial No.	To connect	Bolts and Nuts			Iron washers			Nails 3″ long and $\frac{3}{8}$″ diameter	Spikes 6″ long $\frac{1}{4}$″ diameter	Constructional remarks	General remarks
		Diameter	Length	Number required	Thickness	Diameter	Number required				
		inch	inch	Nos.	inch	inch	Nos.				
1	$1\frac{1}{2}$-inch planking with main decking ..	..	..	..	..	..	..	200	..	1*a*	
2	Main decking to roadbearers ..	..	..	..	..	..	..	..	160	2*a*	
3	Roadbearers to bridge seats ..	$\frac{3}{4}$	10	8	..	..	..	..	..	3*a*	Use $\frac{3}{4}$″ drift bolts instead of bolts, nuts and washers. See Fig. 8 of 15 feet span bridge.
4	Roadbearers to transoms	$\frac{3}{4}$ or $\frac{3}{4}$ or $\frac{3}{4}$	10 10 ..	16 8 ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	4*a*, Fig. 16 4*b*, Fig. 17 4*c*, Fig. 20	,, ,, ,, ,, ,, ,, ,, ,, ,,
5	Transom to trussed beams	$\frac{3}{4}$	6	16	..	..	..	..	..	5*a*, Fig. 21	,, ,, ,,
6	Guard block and wheel guard to main decking	$\frac{3}{4}$	12	12	$\frac{1}{4}$	2	24	..	..	6*a*	
7	Rail post to main decking	..	..	..	..	..	..	..	..	7*a*	Also see Fig. 7 of 15 feet span bridge.
8	Hand rail to rail post ..	$\frac{1}{2}$	9	20	$\frac{1}{4}$	2	40	..	..	8*a*	See Fig. 1 of 15 feet span bridge.
9	Inclined strut to rail post and decking ..	..	..	..	..	..	..	..	20	9*a*	See Fig. 7 of 15 feet span bridge.
10	Trussed beams :— (*a*) straining to strut..	$\frac{1}{2}$	7	48	..	..	..	..	..	10*a*, Fig. 14	Use mild steel bent strap.
	(*b*) strut to abutment	..	..	..	..	..	..	..	..	10*b*, Fig. 19	Depending on type of abutment.

NOTE ON CONSTRUCTIONAL REMARKS FOR

(1*a*) Same as that for 1*a* in Table II Hardware required for 15 feet span of bridge.

(2*a*) Same as that for 2*a* in Table II Hardware required for 15 feet span of bridge.

(3*a*) Same as that for 3*a* in Table II Hardware required for 15 feet span of bridge.

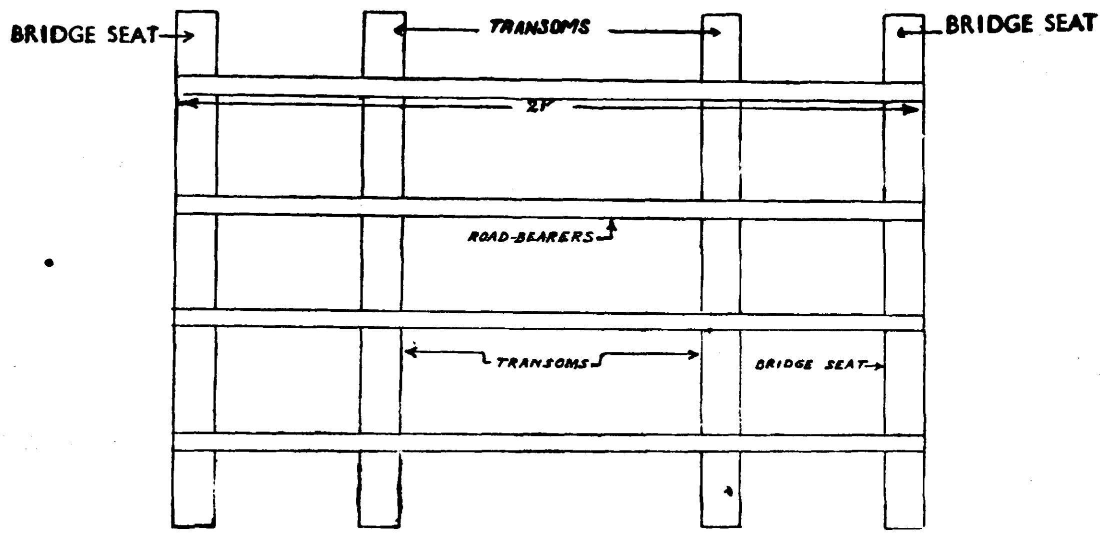
(4*a*) When each roadbearer consists of

$\left.\begin{array}{l}\text{2 Nos. 5' 9'' long}\\ \text{1 No. 10' 6'' long}\end{array}\right\}$ roadbearers (see Fig. 16).

(4*b*) When each roadbearer consists of

$\left.\begin{array}{l}\text{1 No. 15' 9'' long}\\ \text{1 No. 5' 9'' long}\end{array}\right\}$ roadbearers (see Fig. 17).

(4*c*) When each roadbearer is of one piece length of minimum 21 feet (see Fig. 20).



ARRANGEMENT OF ROADBEARERS

FIG. 20

(5*a*) See Fig. 21.

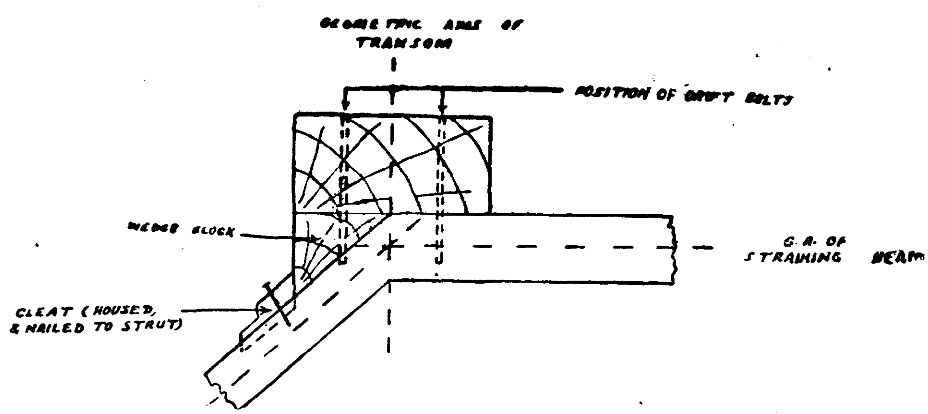


FIG. 21

(6a) } Same as that for 4a, 5a, 6a, 7a in Table II.
(7a)

(8a) } Hardware for 15 feet span Girder bridge.
(9a)

(10a) Straining beam joined to strut with mortice and tenoned mitred [and wrought iron bent straps four per trussed beam (Fig. 4) when angle a in Fig. 11 is greater than 45°].

(10b) See Fig. 19.

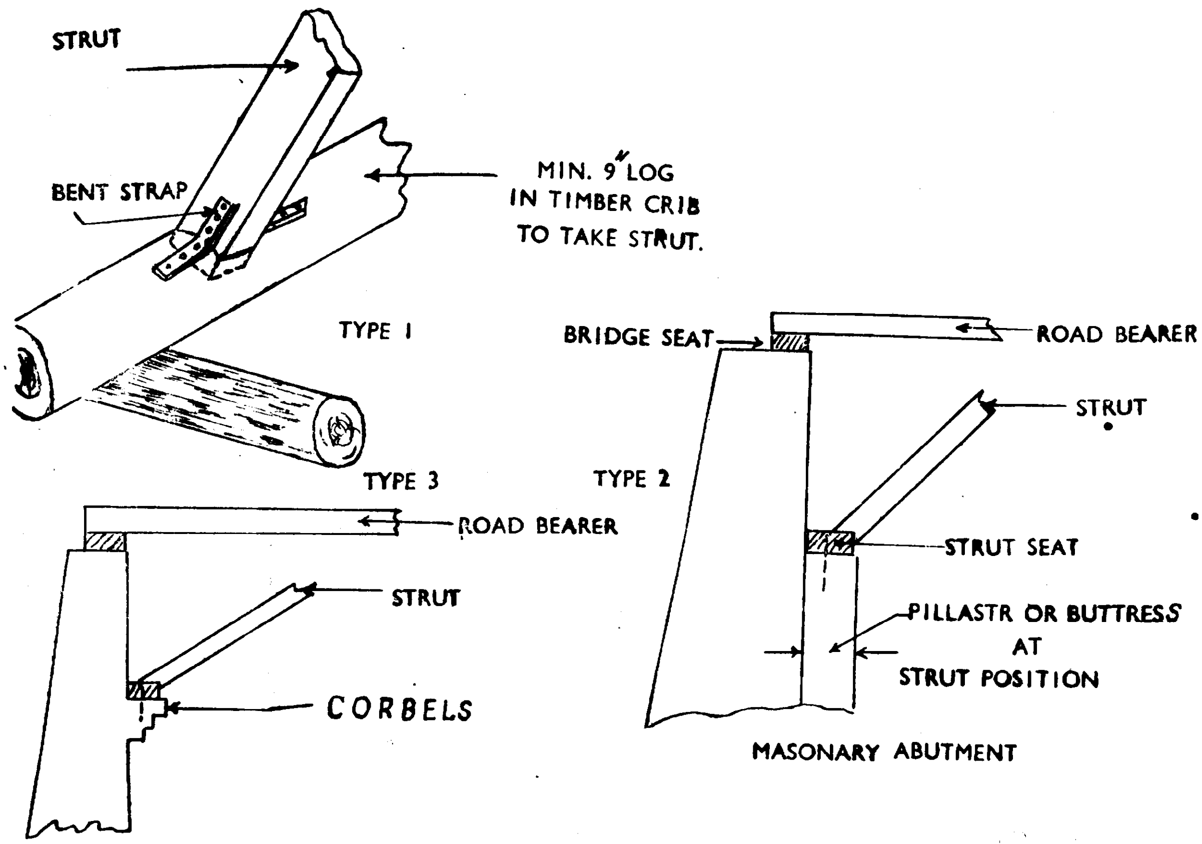


FIG. 19

Type 1 : When timber crib abutment is used.
Type 2 : Masonry abutment with pilasters or buttresses.
Type 3 : Masonry abutment with corbels.

(Continued)

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IMPORTANCE OF EDUCATIONAL PROPAGANDA

BY SHRI MAHENDRA PRAKASH, M.SC., B.SC. FORESTRY (EDIN.)

There is gross ignorance exhibited by some people about forestry matters. The public do not understand the need of forests conservation, development and extension. Even some officials do not regard forest administration as integral part of civil administration.

In our educated classes, a 'forest consciousness' has got to be created, since it is from such people that the supply of officers, politicians, administrators and policy-makers is obtained. Importance of educational propaganda in schools is equally great because school children grow into the citizens of the future.

In Trinidad an annual series of lectures is arranged for the school teachers. In African countries forest officers give talks to the chiefs, natives and to students. Demonstrations are also organized. In Canada railway carriages are decorated by advertisements telling the travellers the dangers of fire in forest. In England, the Forestry Commission issues leaflets and films which are shown in cinema halls and in schools.

In Finland "Forest Propaganda Bureau" has during the last 20 years supplied 3,300 articles to 120 different newspapers. 'Tree Planting Day' is also being observed, and the "Scout Forest Badge" is given to scouts passing a test.

A genuine attempt should be made to educate our public opinion. The aims and benefits of forestry should be explained to the masses through lectures, demonstrations,. excursions, museums, exhibitions, pamphlets and articles in the press. We can thus invite co-operation from the public and forestry can become a pleasing occupation.

Formations of Societies and Associations, etc.—In Great Britain 'The Empire Forestry Association' was established in 1921 "to foster public interest in forestry". 'Men of the Trees' Society in England strives for "preservation of trees and for the reforestation in many countries". "Green Cross Society" of London is interested in planting and marking of trees and Roads of Remembrance and in the safety of plants, trees, flowers, birds and animals. It advocates National Parks and nature reserves in every country.

The object of "The Glasgow Tree Lovers' Society is to plant trees wherever possible and to assist in the preservation of trees".

In America, they have the labels "Prevent Forest fires" on the match boxes to tell the people that while in the forest they should extinguish the cigarette ends or the match sticks before throwing.

By "Trees for to-morrow" program of Wisconsin (U.S.A.) on the average 5,00,000 trees a year are distributed and 10,000 dollars awarded in Forestry Scholarships. "The Jewish National Fund" is collecting money to plant trees in Israel.

Tree Planting and Keep Green Campaigns.—Tree planting weeks and tree-planting programmes go a long way towards creating tree-mindedness in our masses. The City of Edinburgh Education Authority started holding 'Arbor Days' with the object of giving school children a knowledge of forestry and "to increase their respect, care and appreciation of trees".

In America Civic and business organizations are co-operating in the campaigns for forest development under the slogan "Keep America Green". Many of the States in America are pledged to the 'Keep Green' campaign.

A concern distributed 14 lakhs paper bags with printed message "Prevent forest fires and Keep Georgia Green" to grocers and different shops. In Arkansas under the "Keep Arkansas Green" slogan they celebrate forest festivals every year for the farmers. Some States distribute plates with the Keep Green emblem that should be attached to the number plates of private cars. In Oregon 20,000 boys and girls of ages 8 to 18 have been enrolled as "Green Guards".

National Parks.—Forest consciousness can be inculcated in the people by the creation of National Parks by keeping aside large tracts of forests 'as pleasing ground for the benefit and enjoyment of the people'.

Importance of Visual Education.—A very important way of educating the millions of illiterate masses is through demonstrations. The Forest Department can show villagers practical methods of saving their lands from the menace of erosion, the method of planting trees as shelter-belts to save their fields from strong hot or cold drying winds, or the creation of village fuel plantations.

Films as a medium for carrying knowledge 'to the very fringe of the huge population', play even a greater part in teaching the masses the importance of forests, and the protection they afford and amenities they bring.

Press can help a Great Deal.—The press can help appreciably by publishing instructive articles and by popularizing tree-planting campaigns. Private and Industrial concerns contribute newspaper and magazine space for such educational propaganda through the press in America.

A REQUEST TO OUR READERS

The 1950 issues of the *Indian Forester* are being despatched to the subscribers regularly and should normally reach the destinations in India by the middle of the same month and those in the foreign lands by the middle of the next month. Complaints about the non-receipt of their copies should be made by the readers within a period of 1 month of the dates mentioned above. The Readers are requested to co-operate by putting in their claims to fresh copies within the periods mentioned above.

CUPRESSUS TORULOSA—A TIMBER WITH A BRIGHT FUTURE

(A plea for raising large scale plantations of the species)

BY G. S. MATHAUDA, M.A., A.I.F.C.
(*Statistical Assistant Silviculturist, Forest Research Institute*)

Abstract.—*Cupressus torulosa* is a fine timber eminently suited for a number of specialized industries such as pencil making, battery separators and vats for storage of corrosive chemicals. The total requirements of these industries at a conservative estimate are $2\frac{1}{2}$ lac cubic feet per annum. The tree can be propagated easily and with advantage on comparatively dry and hot slopes not well suited for carrying *deodar*. It is thus a timber with a bright future. Action should be taken to create large scale compact plantations capable of meeting the above requirements.

Till recently practically the whole of our demand for 1st quality pencils was being met by timber imported from abroad. The Indian factories during the last decade have been manufacturing some good quality pencils, but they have been importing the wood for this purpose from America and Africa in the form of slats. The total estimated requirements of timber for pencils for home consumption is about one lac cubic feet per annum. The timber should satisfy rigid specifications by way of colour, texture, straightness of grain and its seasoning and warping properties. The American Incense Cedar (*Libocedrus decurrence*) and the African cedar (*Juniperus procera*) dominate the world pencil market to-day and for high quality stuff are imported in large quantities by the manufacturers all over the world.

A vigorous search for local substitutes made at the Forest Research Institute, Dehra Dun has proved that out of the numerous woods found in the Indo-Pakistan sub-continent *Juniperus macropoda*, *Cupressus torulosa* and *Cedrus deodara* fully meet the requirements of the case. The first two especially are as good as the American cedar with *deodar* closely following them. They are all decidedly superior to the African cedar. Out of the three only *deodar* is at present available in large enough quantities. But its comparatively limited resources are already so much over-taxed that it is worth while investigating the possibilities of raising production of the other two which are also superior to it for pencil making.

Juniperus macropoda, a moderate sized tree, is found chiefly in Baluchistan and N.W.F.P. both now lying in Pakistan and to some extent in the inner arid Himalayas up to Nepal. The area under it is fast shrinking for various reasons. It is extremely slow growing and may take 240 to 720 years to attain a girth of 6 feet. The trees are mostly crooked, gnarled and branchy and the wood is of no other great use. What is worse, we do not know how to regenerate the existing forests or to raise it in large scale plantations.

The position regarding *Cupressus torulosa* fortunately is much better. It occurs at 6,000 to 9,000 feet elevation in the outer Himalayas from Chamba to Nepal in the form of comparatively small patches or isolated trees. Usually it occupies dry, hot slopes avoided by the other conifers growing in the zone. Though commonly met on limestone rock and shale, it is not particular about soil and climate. It has been easily cultivated outside its natural zone under a variety of conditions, e.g., at Dehra Dun, Calcutta, the Punjab plains and South India. As compared with *deodar* its distinguishing feature is that it will grow well on exposed sites unsuited for, or at the most capable of producing poor quality *deodar*. The tree attains the same size as *deodar* and is not much inferior to it in growth rate.

Cupressus torulosa, according to Pearson and Brown and Troup, is a timber of excellent quality. It is a first class carpentry wood suitable for pattern making and other high quality work. It is a good substitute for *deodar* for practically all purposes. The heartwood is light brown in colour, fragrant and very durable. The timber is eminently suited for high quality pencils and pen-holders. It is the best Indian timber for battery separators and for making vats for storing corrosive chemicals. It has thus got a very bright

future provided an adequate and sustained yield can be produced. The total requirements of timber for the above 3 uses at a conservative estimate would be $2\frac{1}{2}$ lac cubic feet per annum.

We should, therefore, place *Cupressus* in the list of favoured species and take immediate steps to raise plantations capable of putting forth an appreciable yield. In its natural zone of occurrence, unfortunately for *Cupressus*, *deodar* has been monopolizing all the attention from the forest officers. So much has been the craze for *deodar* (as for teak and other well known valuable species elsewhere) that it has often been introduced on unfavourable sites repeatedly with results disastrous from the financial as well as ecological point of view. *Cupressus* would be a very good substitute for most of such sites. This fact has been realized some times and the species has actually been successfully raised in difficult situations. But the action has been inconsistent. A fair deal for *Cupressus* is wanted. The proper thing would be to allocate areas suitable for *deodar* and *Cupressus* separately right from the beginning in order to raise the latter in compact plantations which can assure sustained yields capable of catering to regular industries and of creating new ones.

SOME EXPERIENCES IN A TIGER CAPTURE

BY M. W. PALEKANDA, LL.B., B.SC., M.F. (WASH.)
(*District Forest Officer, Chikmagalur*)

In the later half of last year, orders were received for the capture of tigers for the Zoological Gardens at Mysore. Soon, we thought of the tiger infested forests of Sakrepatna, hardly eight miles from Kadur, for our study. Investigations were started to study the movements of the tigers and the cattle tracks through which the tigers frequented. Villagers were consulted and the cattle watchers questioned and with the knowledge thus gained, a spot was finally selected on the side of a cattle track which wound it's way through thorny and matted bushes of Lantana and Randia. Under a well grown bush, a pit 8×8 feet with a depth of 20 feet, was dug, as tigers are known to have cleared up to 16 feet and escaped in the past. Care was taken to make the sides of the pit almost smooth and vertical, so that no kind of grip was afforded to the tiger to climb out in stages. The pit was carefully covered and camouflaged so well, that the very architects of it, doubted the presence of a 20 feet deep trap underneath, the next day. An entrance about 3 feet wide was allowed, opening out to the cattle track, and the pit around fenced with twigs and green leaves, close to the edge except at the side opposite to the entrance, where just a little space was provided for the bait to stand. No other space was left for the tiger to by-pass the pit and reach the bait.

The bait—a buffalo was tied each evening before dusk in the alloted spot, and released in the morning. This operation was carried out methodically for several days. When our patience was coming to an end, the watcher one morning reported that a tiger had fallen into the pit, but had escaped. This was incredible, since a tiger had never in the past cleared a pit of over 16 feet. We hurried to the spot and examined the new gaping pit and discovered to our amazement, that a tiger had actually fallen into the pit and had leapt over. Ample evidence of it's attempts to escape by way of innumerable scratches on the sides of the pit, shavings of nails, hairs and blood stains, was there. The tiger's pug marks on the sand indicated that after leaping out of the pit, it had limped it's way to a hiding, nearly a mile away, bruised on the feet. In the scare of it's escape, it had not even cared to look back to attack the bait again.

With this disappointment, coupled with the valuable experience of a tiger's capacity for leaping a 20 feet pit, we got the pit deepened further by another 3 feet and had some straw put in at bottom to serve as a cushion to the falling brute. The operation was carried out as carefully as before with the same unfortunate buffalo. After about a fortnight of patient waiting and examining of the trap daily ; we got the report that this time a tigress had fallen in the pit.

To our surprise, we found the bait missing leaving a pool of blood at the spot where it had been tied. Upon careful examination of the locality around, the carcass was discovered eaten up in a secluded spot under a bush about a furlong away. Drag-marks were clear leading from the pit accompanied by tiger pug marks. This was another strange experience, and never known to have occurred in the past for the bait ordinarily escapes unburt, as the tiger falls into the pit before pouncing on it.

In this case, not only had the buffalo been killed, but it had been dragged away and eaten up. My investigation indicated that actually a tigress and a tiger had come the previous night to the pit, and the tigress being more greedy and less cautious had ended in the pit, while the tiger shrewdly got round the gaping pit and took the bait.

Our ultimate success in capturing a full grown tigress of over 10 feet for the zoo after these strange experiences, was no doubt a matter of satisfaction and pride to us. More than the success, the knowledge of a tiger leaping out of a 20 feet pit, and while in a pair, the tigress being the one first to attack the prey, were experiences deserving of a place in the "Indian Forester" for the information of those interested in the habits of tigers.

ABSTRACTS

SWELLING PROCESSES IN WOOD BY A. NOWAK

(Communications of the Austrian Society for Timber Research, April 1950)

The author has investigated the swelling of wood in various organic solvents. The swelling can be represented by the relation :

$$\frac{A \times r_0 \text{ wood}}{r \text{ liq.}} = \beta_v$$

where A is the quantity of liquid taken up as a % of the oven dry weight of the wood, r_0 the oven dry weight of wood and r liq. the specific gravity of the swelling liquid and β_v the volumetric swelling as a % of the oven dry volume. The results of swelling when plotted as a function of the % of H_2o swelling against the quantity of swelling agent (expressed as % wt. on wood/ density of the swelling agent) are represented by a single straight line with points of inflection at the fibre saturation points for the liquids concerned. The maximum swelling and velocity of swelling vary with the liquid used. The highest value for maximum swelling was obtained with Glycol (107) followed by water (100) prophylene glycol (100), methyl alcohol (89), ethyl alcohol (79), acetone (74), ether (17). The maximum swelling depended on the intensity of the polar group. Hydroxyl (OH) caused the highest swelling followed by the carbonyl group, chlorine, and ether oxygen. The velocity and temperature. The fibre saturation point varied from 4 ·3 (at 200) with ether to 45% with glycerine (at 900) as wt. percent and as vol. % from 6% with ether and Butyl alcohol to 38% with glycol. For the same amount of swelling (19%) the loss compressive/strength with Hexanetriol was only half that obtained with water. It is concluded that the loss in strength is not a function of the degree of swelling but is dependent on the properties of the swelling agent. Increased inter micellar mobility doubtless affects strength decrease, the mobility being influenced by the distance between the 2 micellar surfaces and the viscosity of the swelling agent. Hexanetriol is more viscous than Ancient buried and decayed wood seen from a biological point of view by Dr. W. S. Varossieaa [Biologaande Afdeling Hout van het Centraal Institut voor Materiall onderzoak (C.I.M.O.) te Delft].

II

Prompted by the great timber shortage in Holland, at the suggestion of the Public Works Department the author investigated the wooden pilings of bombed buildings in Rotterdam. The age of the piling varied from 30 to 600 years, and were of spruce (*Picea excelsa*), pine (*Pinus silvestris*) and fir (*Abies alba*). In addition to studying changes that had occurred in these species while buried below ground water-level, for comparative purposes lignite from brown coal and older materials like jet (150 million years old) and wood attacked by fungi under laboratory conditions as well as samples attacked under natural conditions from a ruined Church in the Hauge were included in the study. Both microscopic and microchemical examinations were made.

The oldest Rotterdam samples from below the ground water-level exhibited a prismatic structure (external). This is ascribed to be the result of the lower cellulose content of the outer layers and the irregular distribution of cellulose in these layers. The variation of the cellulose content of successive layers is held to be the specific cause of their different swelling and shrinkage properties, which again are responsible for the development of the presmatic appearance of the surface. The same is held to be the cause for the "cubic rot" caused by fungi.

Decomposition of wood under anærobic conditions is held to start at the surface and to proceed in some parts of the wood more rapidly than in others. Deterioration in the cell wall also proceeds irregularly. The ray cells are "attacked" first, then the fibre tracheids at the boundary of the growth ring and adjacent to the rays.

The progressive disintegration of the cellulose causes a gradual decrease in mechanical strength which in turn may result in failure by shearing. Such mechanical failures were first noticed in samples 260 years old (spruce and pine). Although deterioration of the cell walls is first observed in late wood the loss of strength on the other hand shows up earlier in early wood. Older samples showed a similarity with lignite and petrified wood samples and had a grainless structure and from these observations it is concluded that the changes in the cell walls of the wood fibre are identical with those which take place in wood during conversion to coal. As a further proof that the deterioration of wood in the soil under anærobic conditions is not caused by fungi, the absence of hyphæ and bore holes excepting in one case is cited.

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DRAFT STANDARD FOR CREOSOTE AND ANTHRACENE OIL

Railway sleepers and wooden poles for telegraph and telephone lines used in India are, due to the great distances, naturally very considerable both in quantity and cost. Proper preservation of these materials as well as other timbers in general use, is thus an important matter of national economy. The Bitumens and Tar Products Sectional Committee of the Indian Standards Institution has, therefore, brought out a draft standard for creosote and anthracene oils for use as wood preservatives.

Two types of creosote oil and one type of anthracene oil have been standardized in the draft standard. Requirements of these types for such characteristics as fluidity, specific gravity, moisture content, matter insoluble in benzene, etc., have been specified. Test methods for the determination of these characteristics are given in five appendices. Several figures have also been included in the standard to give details of the apparatus needed for the tests.

The draft standard has been circulated for eliciting critical review and comments from interests in India and abroad. Comments should reach the Director, Indian Standards Institution, 19 University Road, Delhi 8, by September 20, 1950 at the latest.

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ISI REPORT ON WEIGHTS AND MEASURES

Copy of Press Note issued by Press Information Bureau, Government of India, New Delhi, Dated July 13, 1950

The systems of weights and measures in use in India are as numerous as they are complicated. This diversity is the source of many fradulent practices in trade. The need for standardization has always been felt and attempts date as far back as 1801. The results achieved so far are, however, meagre.

The special committee on weights and measures set up by the Indian Standards Institution last year to recommend ways and means for terminating this wasteful diversity, finds a solution in the adoption of the metric system. The report of the special committee, which is unanimous, is now complete and has just been issued by the Indian Standards Institution in a special publication.

Based on a country wide concensus of opinion of scientists, technologists, industrialists and Government departments, the Committee's recommendation for the adoption of the metric system envisages a change-over in three stages extended over a period of about 15 years. A preparatory stage of three to five years for intensive dissemination of information

on the new system, would be followed by a change-over stage of about the same period and a final stage for over-all transition. After that period, the only system accorded legal recognition would be the metric system.

For the implementation of the Committee's recommendation, the report stresses the need for early Central legislation for the recognition of the metric system and the creation of an agency to co-ordinate all related measures for the change-over. Introduction of decimalized currency is also recommended in the early stage of the change-over.

In regard to the nomenclature of the new system, the report records the view that the international nomenclature should be used, unless Parliament decides to have an Indianized system. In the latter contingency, however, it has been advised to avoid the use of the existing names, such as seer and guz for kilogram and meter.

Before presenting the recommendations of the Committee, the Report traces the historical background of the movement for standardization of weights and measures since 1801. A brief summary of the proceedings of the Committee at its three sessions and the views of various organizations elicited in reply to a questionnaire issued by the Committee in the early stages of its deliberation, are also included in an appendix.

Copies of the Report, which is priced at Rs. 2 each, may be had from the Secretary (Administration), Indian Standards Institution, 19 University Road, Civil Lines, Delhi.

UNIMETER

A Versatile Field Instrument for Foresters, Surveyors, Engineers and Plane-tablers

BY K. KADAMBI, M.SC., D.SC. (MUNICH), DIP. FOR. (HONS.)
(*Assistant Silviculturist, Forest Research Institute, Dehra Dun*)

The UNIMETER, is a multi-purpose instrument designed and constructed by the writer in 1944, (when holding the combined charges of Working Plan Officer, Superintendent of Forest Surveys and Principal, Mysore Forest Ranger School, Bangalore). The primary object was to provide the forester and the plane-tabler in India with a simple, fool-proof, handy and ready instrument which would enable them to carry on the fieldwork required of them from day to day without having to use a number of field instruments like the Ceylon Ghat Tracer, Abney Level, Brandis Hypsometer, Tangent Clinometer, Cross Staff, Right-angle Prism, etc., some of which are neither handy enough nor accurate enough. Experience as head of the Forest Ranger School also showed that not all students could easily master the use of the several field instruments during the short period of their training, and that while some of them took kindly to particular instruments they neglected the others or sometimes developed even a distaste for their use. It was felt that an instrument capable of all-round service would be useful to foresters and plane-tablers. Further, few can afford to purchase several instruments at the same time, or can afford the field assistance which some of them require. An attempt has been made to combine in the UNIMETER the utilities of important field instruments, to remove their disadvantages if any, and also to make the combined instrument *simple and portable*. This instrument has had a fairly long period of satisfactory field trials.

Description of the Instrument.—Fig. 1 is a general close-up front view of the Instrument. It consists of three main parts : (1) an anchor shaped body called the '*Anchor*', (2) a levelling '*Pedestal*' to which the *Anchor* can be attached in the vertical plane and (3) a '*Tripod*' surmounted by a screw-head to which the *Anchor* or the *Pedestal* could be fitted either individually or together.

The *Anchor*, which is small enough to be able to slip into one's waist-coat pocket, bears on its broad face graduations marked on the arc of a circle indicating natural tangents, degrees and percentages. A *Cross* is attached to it, which helps in reading the graduations and has also an arrangement which enables one to view through along two lines of sight fixed exactly at right angles to each other. A spirit-level is attached to the rear face of the *Anchor* which permits of levelling the instrument in the vertical plane (Fig. 2). The *Anchor* can be suspended vertically on one's finger by means of a steel ring attached to it at its top end. When it is so suspended, the bubble of the spirit-level centres. Three cylindrical pegs on the back of the *Anchor* enable its being placed on its back while in use along with a Survey of India Plane-table (Fig. 2). A flange with an internal screw thread fixed to the back of the *Anchor* permits of its being mounted on the *Tripod* while in use in a horizontal plane (Fig. 3).

The *Pedestal* consists or an upper and a lower plate, hinged together at one end so as to move up or down like a jaw by turning a vertical levelling screw on the other ; this arrangement enables one to level the *Anchor* which can be attached to the *Pedestal* while in use by means of two thumb-screws. The bottom of the *Pedestal* has three knobs on which it can rest upright while the Instrument is in use along with a Survey of India Plane-table to serve as a Tangent Clinometer. In addition to the three knobs there is also a flange with internal screw-threads fixed to the bottom face of the *Pedestal* to enable the Instrument being fixed on the *Tripod*.

The *Tripod* has three legs (triangular on cross section with a rounded outer face), which fold together to form a round pole. It is surmounted by a screw-head in which the *Anchor* can be fixed in the horizontal plane by itself or in the vertical plane along with its *Pedestal*, and is then free to move round. To the top plate of the *Tripod* can also be fixed a metal rod bearing at its free end an arrangement for suspending the *Anchor* on its steel ring while in use (Figs. 1 and 2).

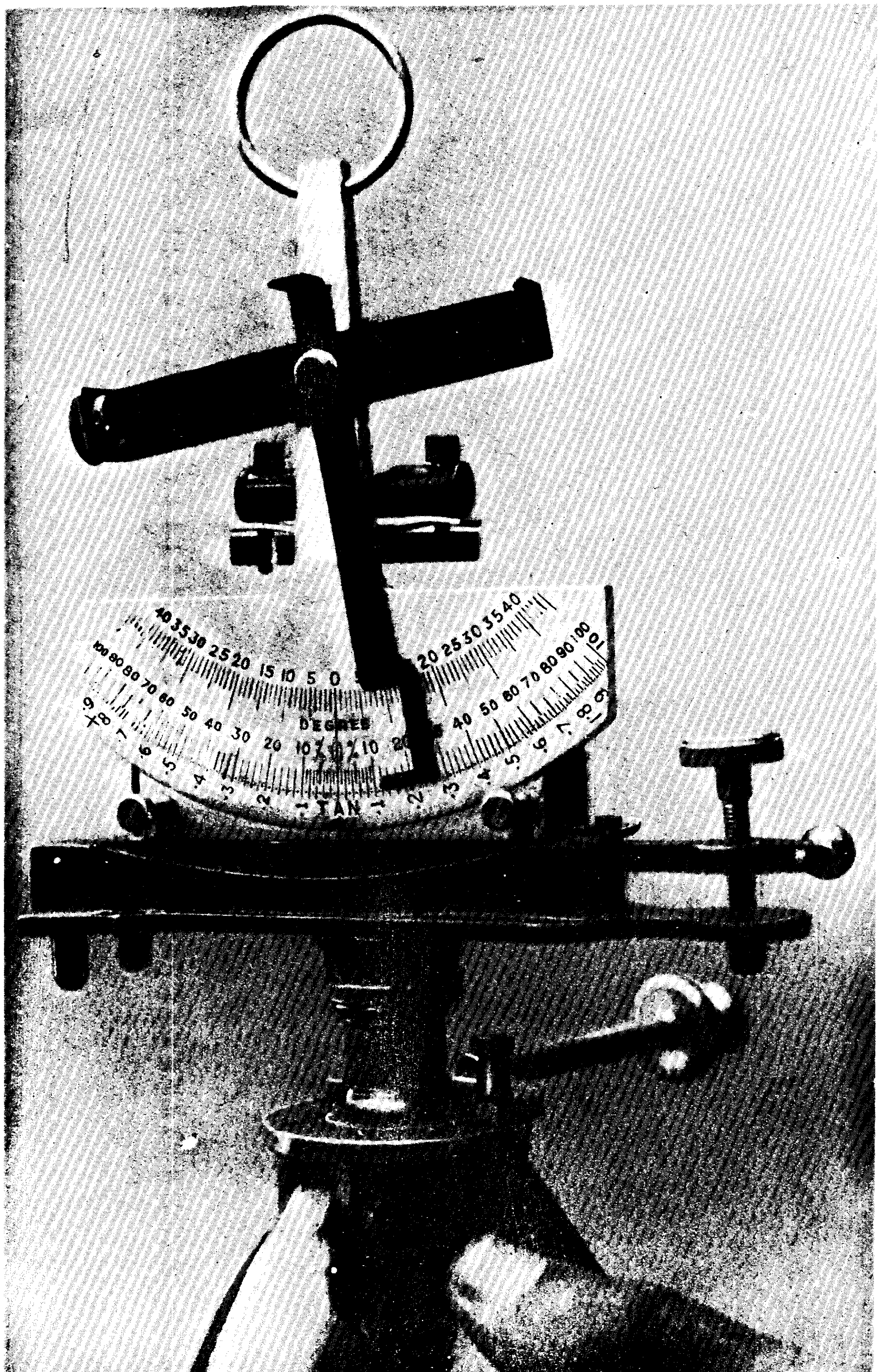

FIG. 1.—Kadambi's UNIMETER, front view, approximate natural size.

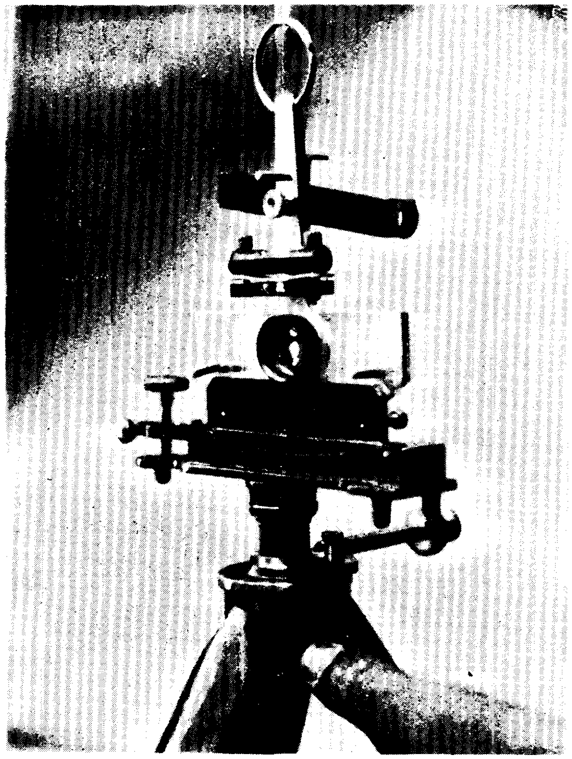

FIG. 2.—Kadambi's UNIMETER, back view.

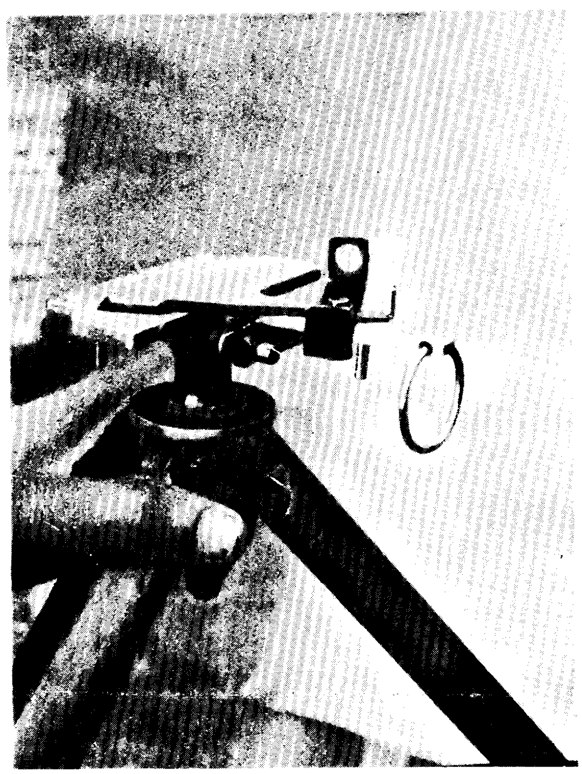

FIG. 3.—Kadambi's UNIMETER. Anchor mounted on the tripod.

The following is a brief description of the methods of use :—

(1) *For use like a "Ceylon Ghat Tracer" in road alignment.*—Set the Cross on the *Anchor* to the given slope or gradient against the graduations on it, and proceed with the alignment (without the *Pedestal*) either suspended on the thumb or on the rod provided for the tripod ; have the feet of the tripod clasped together. After some practice the tripod can be dispensed with, the hand being sufficiently stable when supported against the rim of the aligner's hat to proceed with the work. For road alignment as above the *Pedestal* is unnecessary. If greater accuracy is required the *Anchor* should be fixed to its pedestal and the two together on the tripod.

(2) *For laying out in the field road curves, right angles, acute and obtuse angles.*—Fix the *Anchor* horizontally (without the *Pedestal*) on the *Tripod.* The Cross now gives you two lines of sight-normal to each other—one line connecting the two ends of the upper limb of the Cross and the other connecting the lower. When the Cross is placed against the zero of the graduation this line of sight cuts the pointed steel nail fixed on the front face of the anchor. Thus the instrument is a perfect cross-staff. Any other angle can be made by setting the indicator on the required graduation. Perfect road curves, right angles and other angles (obtuse or acute) can thus be marked in the field.

(3) *For levelling.*—Fix the *Anchor* to the *Pedestal* and screw the whole on to the top of the *Tripod.* The instrument can now be set perfectly horizontal by means of the levelling-screw and the spirit-level and it can now be used for levelling like any other levelling instrument. It has been found in practice to be quite accurate for its size and simple construction.

(4) *For use as a Hypsometer or Abney Level in measuring heights of trees.*—Suspend the *Anchor* on the thumb standing at any convenient distance where the foot of the tree and the tip of the crown are clearly visible. Now move the Cross until the cross-fibre in it cuts the tip of the tree-crown. Steady the instrument, if required, by supporting your finger against the rim of your hat during the operation. Measure your distance from the base of the tree and proceed to calculate the height just as you would do with either a Brandis Hypsometer or an Abney Level making use of the degree, percentage, or tangent readings. For more accurate work fix it on the *Tripod.*

(5) *For determining sectional heights of standing sample trees, tree bole diameters, crown spread, crown height, etc.*—For measurement of bole diameter and crown spread fix the anchor plate without the pedestal on the tripod and read the angles or tangents between one edge of the crown or bole and the other edge of the crown or bole respectively. By then measuring the distance from the observation point to the bole of the tree the width of the crown or the diameter of the bole can be calculated. For sectional bole height and crown height, etc., fix the *Anchor* with *Pedestal* on the *Tripod* when the full-height of the tree as well as sectional heights, height of crown, etc., can be determined.

Other measurements of standing trees.—It is easy, for example, to determine of points on the bole of a standing tree representing $\frac{1}{4}$ the tree-height, $\frac{1}{2}$ the tree-height and so on.

(6) *Determining clinometric heights while working with the Survey of India Plane-Table.*—Rest the instrument upright (*Anchor* fixed to the *Pedestal*) on the plane-table on the three knobs of the *Pedestal* and view the point whose height has to be read, through the cross-fibre on the upper limb of the Cross. Then level the instrument till the bubble centres. Now raise or lower the line of sight viewing through the cross-fibre, until it cuts the point. The tangent is then read off directly on the anchor plate by means of the indicator. Mistakes made in tangent readings by beginners while using the Survey of India peep-hole Tangent Clinometers are here not possible because the reading is automatically given by the indicator.

(7) *For contouring, locating topographical details and measuring horizontal angles between two widely separated points while plane-tabling.*—The instrument can be used for this purpose with or without the pedestal. If you have to measure vertical angles fix the *Anchor* on the pedestal and rest the whole on the plane-table. If you have to locate points horizontally separated detach the *Anchor* from the *Pedestal* and support it flat on its back upon the plane-table. The line of sight will now serve as a miniature sight-vane and this lies exactly at

right angles to the other line of sight on the Cross, which again serves as a miniature alidade. By shifting the indicator against the graduation the horizontal, tangential or angular divergences can be read off.

(8) *For stock-mapping of forest growth in working plan fieldwork.*—Used in conjunction with a marching compass the instrument can render valuable help in stock-mapping forest growth by enabling measurements of differences, both angular and tangential, between points whose location on the map in relation to a known point is required.

(9) *During cadastral survey, for taking offsets.*—Fix the anchor plate without the pedestal on the tripod and close the three legs of the tripod or rest the tripod on the ground, according to convenience. The two lines of sight on the Cross are now a perfect right angle.

(10) *Measuring horizontal and vertical angles.*—The instrument can be used for rough and ready triangulation work under conditions where the natural features are close together and clearly visible from one another. Its scope in this respect and range of vision are, however, very limited owing to the absence of a telescope.

SEASONING PRACTICES AND MANUFACTURING OPERATIONS FOLLOWED BY VARIOUS WOOD WORKING INDUSTRIES OF U.S.A., CANADA AND ENGLAND

PART III

BY M. A. REHMAN, M.SC., A.R.I.C., A. INST. P.
(*Officer-in-Charge, Wood Seasoning Branch, Forest Research Institute, Dehra Dun*)

(*Continued from March 1950 issue*)

SUMMARY

Part III of the article deals with the seasoning of veneers for making plywood, and with the seasoning of wood, and the manufacturing technique followed by flooring strip makers. A flooring mill is very much like a box-shook factory, hence of interest to the timber industry of this country.

(*a*) *Mechanical veneer dryers.*—Most of the American and Canadian plywood factories visited were fitted with the latest types of Peeling lathes, Hot presses and High Frequency drying equipment. During these visits all known types of American mechanical veneer dryers, viz., Coe Roller Dryer, Merritt Hot Plate Dryers with and without fans, with and without cooling unit, Proctor and Schwartz Dryer with conveyor belts of wire as well as those of helical springs were seen in operation.

Proper seasoning of veneers before gluing is an important step in the manufacture of plywood. In order to cope with the large production of plywood factories, several types of mechanical dryers have been evolved in America. These are metal chambers, say 25 feet to about 100 feet long, heated by means of steam pipes and in most cases fitted with fans as well. Green veneers are fed at one end of the dryer and they are made to move towards the other end by mechanical means. They get dried in a few minutes during the course of this movement, the speed of which may vary within wide limits, say from 1 foot per minute to 15 feet per minute for drying veneers for ordinary commercial plywood. A brief description of different types of dryers seen is given below :—

(*i*) *Coe Roller Dryer.*—A small experimental veneer dryer especially fabricated by the makers for research work for the Forest Products Laboratory, Madison, U.S.A., was seen. In this type of machine the veneers move from the green end towards the dry end between metal rollers. The experimental dryer was made up of five enclosed sections, each 6 feet long, making a total enclosed length of 30 feet.

This machine was one line (deck) high, equipped with two layers of 6 feet long rollers, 3 inches in diameter, placed 4 inches apart, centre to centre. A layer of veneers was continuously fed between these rollers. The heating pipes were distributed along the length of the dryer. It had two centrifugal fans at the intake end, which forced air into the dryer from the two sides. The air moved along the length through the roller box, and it came out through a duct at the other end of the dryer. Part of the used air was exhausted into the atmosphere and part of it was recirculated. There was no appreciable temperature drop along the length of the dryer. There was an arrangement for giving free steam towards the end of the dryer for conditioning of veneers, if necessary. The dryer was fitted with automatic temperature and humidity recorder controllers. Birch veneers 1/16 inch in thickness were dried in 8 to 10 minutes.

Also saw two large Coe dryers of commercial size, 96 feet long, 5 deck high, having a cooling chamber at the end. Birch veneers 1/16 inch in thickness were dried at 165°F in 5–6 minutes in these dryers. Core stock 1/8 inch in thickness took 15 minutes for seasoning.

(*ii*) *Merritt Hot Plate Dryer.*—In this type of dryer, the veneers are seasoned by coming in contact with hot plates at regular intervals during the course of their movement from one end to the other end of

the dryer, which may or may not have the fans for the exhaust of moist air. The Forest Products Research Laboratory, Princes Risburough, England, has a small experimental Merritt dryer, which was examined. It was 15 feet long, 3 deck high, provided with a fan for the exhaust of moist air and having a cooling section at the dry end.

Birch veneers 1/16 inch in thickness took 10 minutes to dry. Thicker veneers, 1/8 inch in thickness, had to be passed twice through the dryer taking about 20 minutes in all for seasoning.

The operation of several other Merritt dryers, of different sizes was seen in plywood factories. In one factory birch veneers 1/16 inch in thickness were dried at 180°F in 8 minutes. Another modern factory dried birch veneers 1/16 inch in thickness in its 24 feet long, four deck dryer, in 5 to 6 minutes at 165°F. Very thick core stock took 30 minutes to dry. This dryer had an exhaust fan in the middle and a cooling unit at the end.

(*iii*) *Proctor and Schwartz Dryer.*—It is a veneer dryer in which the green veneers move with the help of endless wire belts. The dryer is also fitted with fans on the sides along the length for blowing air which moves towards the two ends, drying the veneers on way.

The operation of a four deck dryer, fitted with two fans in the middle, one on each side, was watched in a plywood factory. The green veneers were fed in two decks from one end and in the other two decks from the other end. A temperature of 212°F was maintained for drying birch veneers 1/16 inch in thickness, which took 5 to 6 minutes.

The operation of a special type of Proctor dryer fitted with helical springs running longitudinally in the form of endless belts was also seen. This type of dryer is very wide (13 feet wide in this case) and is specially suitable for the seasoning of sliced veneers for decorative lamin-boards. The veneers are collected in the same order in which they come out of the log on slicing. They are then moved to the dryer in heaps and fed into the dryer in the same order. The dryer takes the length of the veneers along its width so that at the dry end the relative position of the veneers in the log is not disturbed. This makes the process of matching the figures on the lamin-boards easy, almost automatic, as dried veneers come out in the same order in which they were sliced from the log.

It may be noted here that the mechanical veneer dryers, though very efficient in operation, are complicated in design and costly. A small commercial unit will cost about a lakh of rupees. A mechanical veneer dryer is almost an essential item for large plywood factories, but for moderate sized factories under Indian conditions, a cheaper and simpler type of dryer such as an ordinary timber seasoning kiln or a tunnel dryer* of masonry work appears to be more suitable.

It is also worth while mentioning here that none of the plywood factories visited had a plywood conditioning chamber, which is used for driving out the extra moisture which the seasoned veneers absorb from glue during manufacture of plywood. There are two reasons for this. The plywood factories in the Western countries either use Hot plate presses for making plywood or they use resin glues in which there is little or no water. However, the Indian factories are likely to use cold presses and casein glue for sometime to come. For these reasons, a plywood conditioning chamber† is also an important requirement of a large number of factories in India.

(*b*) *Flooring strips.*—The manufacture of flooring strips (long narrow pieces of wood used for the construction of the floor of houses), is a very big timber industry in U.S.A., and it is considered a major timber industry in U.K., also. Some of the American flooring mills are the biggest timber factories in the States, fitted with the latest mechanical devices for handling and movement of timber, and with up-to-date seasoning kilns and manufacturing

* The details of the seasoning kiln and the tunnel dryer suitable for veneer drying can be had from the Officer-in-Charge, Wood Seasoning Branch, Forest Research Institute, P.O. New Forest, Dehra Dun.

† The details of the plywood conditioning chamber are given in the I.F.L-65, Utilization, published by the Forest Research Institute, Dehra Dun, price as -/6/- only.

equipment. The observations made during visits to several flooring strip mills in U.S.A., and U.K., are given below :—

Seasoning.—Oak is almost the only timber used for flooring strips in U.S.A. The timber usually comes to the factory in the form of 1 inch thick sawn and unseasoned or partly seasoned planks. These are brought to the open stacking yard in railway wagons or motor trucks. The yard is usually laid with tracks, trucks, transfer trucks and mechanically moving endless belts for conveying timber from one part of the yard to another. The stacking is done on trolleys which are capable of vertical movement mechanically, to facilitate stacking and later unstacking, keeping the top of the stack at breast-height all the time.

The timber stacked on trolleys with the help of battens is air seasoned for 30 to 90 days after which the trolleys are moved into the seasoning kilns for completing the drying operation. The kilns commonly used are of the modern internal fan type with automatic controls. In most of the factories the air seasoned timber is kept in the kiln for about seven days at a temperature of about 180°F, and 40% Relative Humidity, so as to bring the moisture content down to about 9%. After kiln seasoning, the timber is allowed to cool in a shed, then the trolleys carrying the seasoned timber are moved on to the transfer trucks which take them to the machine shop.

Manufacture.—The machining operations start with planing, after which the timber moves on endless belts to a set of circular saws where defective portions are cut-off. The timber then moves on to another set of small circular saws where it is cut into narrow strips. The strips then move on endless belts past the men standing on the way for sorting. At this stage again the defective strips are sorted and removed. The sound pieces then go to thicknessing and moulding machines where they are planed to proper thickness and grooved. The strips again move on endless belts past another set of men who sort them according to lengths. Then they reach the end of the factory where they are graded, marked and bundled.

The English flooring strip mills are comparatively smaller in size. They use Canadian birch, home-grown oak and several species of South American and African hardwoods. The seasoning technique and manufacturing operations followed are the same as in the American factories but on a smaller scale.

(*To be continued*)

A GRAPHICAL METHOD OF STEM ANALYSIS

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Abstract.—A graphical method of stem analysis is described. As compared with the orthodox methods, the fieldwork involved in this method is easier and it yields much more comprehensive information about diameter, height and volume increments.

General.—The article describes a graphical method of stem analysis elaborated under the guidance of the Central Silviculturist, Shri M. S. Raghavan. Mr. Raghavan has used this method during the last ten years, and I have now improved it under his directions and approval. An actual illustration of its application on a Chir (*Pinus longifolia*) tree is given. The fieldwork involved is simple and the method places at our disposal comprehensive information about the life history of the trees so examined.

A. FIELDWORK

1. Mark the breast-height point with a ring round the tree. Calliper two diameters at right angles distinguishing these as ab and cd.

2. Fell the tree. Measure its height. This is best done by measuring from the 4′ 6″ point to top and adding 4′ 6″ to this figure. Divide the stem into 10′ sections from ground level. The first section will thus end 5′ 6″ above BH level and its centre will be 6″ above BH mark. The last section will usually contain odd feet. In case it is 5′ or less group it with the previous section. Mark the mid points of the various sections making suitable allowance for irregularities of growth and branching. Take diameters over-bark at these points and cross-cut the sections preferably with a saw, keeping the cuts at right angles to the axis of the tree.

3. Starting from the stump clean up (with a plane knife, adze or chizel) the various sections to make the growth rings clear.

4. Select two diameters on each section roughly in the directions ab and cd (of step 1 above) and passing through the pith point. In case the pith is eccentric best results are obtained by taking two chords through the pith inclined at angles of 45° to the largest diameter of the section. Placing the edge of a strip of paper along either of the two diameters, mark off the position of the various rings on the particular section taking care to exclude all incomplete (false) rings. Indicate the section number, its height above ground level, the total number of rings present, and the direction of the diameter represented on the strip. Deal in a similar way with the second diameter on the section and with all the other sections.

B. OFFICE WORK

1. *Computation of diameters at different heights corresponding to various ages.*—Take each strip separately. Number the ring marks as 0, 1, 2, 3, etc., starting from the two outermost marks. If the present age of the tree is n years, the diameters at n, n–1, n–2, etc., years are equal to the distances 00, 11, 22, etc. Measure these with a scale or a pair of dividers and tabulate the results for each section in the form *given* in Appendix I.

2. *Computation of heights attained by the tree at different ages.*—On a section paper indicate the heights on a central axis and plot the values of the two diameters, say D_1 and D_2 for the various sections on the two sides of the axis (see Appendix II). Joining up the points representing the same growth rings on the two sides we get a representation of the vertical section of the stem. The height attained by the tree at any age is obtained by producing the lines concerned till they cut the central axis and by drawing parallels to the fixed lines immediately above and taking their mean. For example the height attained by the tree at 5 years age is determined by making the lines AB and CD intersect the central axis and again by drawing through B and D lines parallel to EF and GH respectively till they also intersect the axis and finally taking the mean of these points. The values are recorded in the form as per Appendix III.

3. *Basal Area—Height curves and computation of the volumes attained at different ages.*—Plot the basal area for different ages and at different sections as obtained under step 1,

against heights as illustrated by graph in Appendix IV. A set of curves will be obtained. As they all start at stump height produce them backwards to ground level. The area included between a particular curve and the two axes gives the volume of the tree at that age. The areas may be planimetered or computed mathematically or by counting squares or by using an area comb. As is obvious, the limits of stem-wood of a particular size at a given age can be very easily marked on the appropriate curve and its volume directly determined. The volumes as planimetered for the ages 5, 10, 15 and 21 years are given below. This can be done for each year. The data can be easily utilized for determining form factors and annual increments :—

Age in years	Total volume	Remarks
5	0·6 c.ft.	
10	4·7 ,,	
15	10·2 ,,	
21	18·7 ,,	

4. *Correction from the stump height age to the total age.*—A suitable figure for the age to stump height can be arrived at in the usual manner. The actual age of the tree is obtained by adding this figure to the stump height age.

The method is recommended for its practical utility. As is the case with majority of our Forest Mensuration practices it may not be able to completely satisfy mathematical-statistical methodology. But even in this respect it is not inferior to the other methods. It possesses all the advantages claimed for the orthodox method laid down in the F.R.I. Statistical Code. The fieldwork is simpler as it is much easier to mark off the position of growth rings on a strip of paper than to measure their distances accurately from the section in the field. The information about diameter, height and volume increment of the trees analysed is available for each year. Hence the method has got a special application where the influence of factors like fire, drought, frost, defoliation, lopping and thinnings, etc., is to be studied. More over the quantity of wood of any size contained in the stem, at any point in the life of the tree, can be directly determined. The Graphs present a visible picture of the development of the tree throughout its previous life. If from the outermost line of Graph No. 1 we write the year when the ring is formed thus *1950*, *1949*, *1948*, ... etc., to the centre ; or the five-yearly period 1950, 1945, 1940, etc., and examine the climatic data such as rainfall, or historical data such as fire, thinning, etc., we can attempt to connect growth in height and diameter with such factors. Where the information for each year is not immediately required, office work can be cut down by drawing curves for 5 or 10 year periods.

APPENDIX I

Species :—*Pinus longifolia*

Locality :—Tree growing in the compound of Bungalow No. 16, F.R.I.

(*Diameter measurement*)

SECTION AT 1½ FEET

No. of Growth ring	Corresponding Age	Diameter D_1	Diameter D_2	Diameter Mean	Basal area
0	21	11·40	11·30	11·4	·709
1	20	11·30	11·10	11·2	·684
2	19	11·10	10·85	11·0	·660
3	18	10·80	10·40	10·6	·613
4	17	10·45	10·10	10·3	·579
5	16	10·05	9·75	9·9	·535
6	15	9·85	9·55	9·7	·513
7	14	9·60	9·40	9·5	·492
8	13	9·30	9·15	9·2	·462
9	12	8·90	8·70	8·8	·422
10	11	8·30	8·30	8·3	·376
11	10	7·75	7·75	7·8	·332
12	9	6·90	7·10	7·0	·267
13	8	6·20	6·40	6·3	·216
14	7	5·30	5·45	5·4	·159
15	6	4·50	4·60	4·6	·115
16	5	3·70	3·90	3·8	·079
17	4	2·80	2·90	2·9	·046
18	3	2·05	1·80	1·9	·020
19	2	0·95	0·70	0·8	·004
20	1	0·20	0·10	0·2	·000

SECTION AT 15 FEET

No. of Growth ring	Corresponding Age	Diameter D_1	Diameter D_2	Diameter Mean	Basal area
0	21	10·15	10·40	10·3	·579
1	20	9·85	10·15	10·0	·545
2	19	9·60	9·90	9·8	·524
3	18	9·20	9·45	9·3	·472
4	17	8·60	9·00	8·8	·422
5	16	8·30	8·55	8·4	·385
6	15	8·05	8·15	8·1	·358
7	14	7·65	7·85	7·8	·332
8	13	7·20	7·40	7·3	·291
9	12	6·40	6·75	6·6	·238
10	11	5·80	6·10	6·0	·196
11	10	5·20	5·40	5·3	·153
12	9	4·40	4·45	4·4	·106
13	8	3·60	3·60	3·6	·071
14	7	2·70	2·70	2·7	·040
15	6	1·80	1·80	1·8	·018
16	5	0·70	0·70	0·7	·003
17	4	0·15	0·25	0·2	·000

SECTION AT 35 FEET

No. of Growth ring	Corresponding Age	Diameter D_1	Diameter D_2	Diameter Mean	Basal area
0	21	5·65	5·90	5·8	·184
1	20	5·25	5·40	5·3	·153
2	19	4·80	4·90	4·9	·131
3	18	4·20	4·20	4·2	·096
4	17	3·60	3·60	3·6	·071
5	16	3·00	3·00	3·0	·049
6	15	2·45	2·50	2·5	·034
7	14	2·00	2·00	2·0	·022
8	13	1·60	1·55	1·6	·014
9	12	1·05	1·05	1·1	·007
10	11	0·65	0·65	0·7	·003
11	10	0·20	0·20	0·2	·000

SECTION AT 5 FEET

No. of Growth ring	Corresponding Age	Diameter D_1	Diameter D_2	Diameter Mean	Basal area
0	21	10·85	10·75	10·8	·636
1	20	10·60	10·50	10·6	·613
2	19	10·30	10·20	10·3	·579
3	18	9·90	9·85	9·9	·535
4	17	9·50	9·55	9·5	·492
5	16	9·20	9·25	9·2	·462
6	15	8·95	9·10	9·0	·442
7	14	8·80	8·80	8·8	·422
8	13	8·35	8·45	8·4	·385
9	12	7·85	8·10	8·0	·349
10	11	7·40	7·65	7·5	·307
11	10	6·90	7·15	7·0	·267
12	9	6·20	6·40	6·3	·214
13	8	5·50	5·70	5·6	·171
14	7	4·60	4·85	4·7	·121
15	6	3·80	3·95	3·9	·083
16	5	2·95	3·00	3·0	·049
17	4	2·00	2·00	2·0	·022
18	3	0·95	0·95	1·0	·006
19	2	0·20	0·15	0·2	·000

SECTION AT 25 FEET

No. of Growth ring	Corresponding Age	Diameter D_1	Diameter D_2	Diameter Mean	Basal area
0	21	8·20	8·60	8·4	·385
1	20	7·95	8·25	8·1	·358
2	19	7·60	8·05	7·8	·332
3	18	7·10	7·20	7·2	·283
4	17	6·50	6·65	6·6	·238
5	16	6·00	6·10	6·1	·203
6	15	5·40	5·55	5·5	·165
7	14	4·85	5·05	5·0	·136
8	13	4·45	4·45	4·5	·111
9	12	3·80	3·75	3·8	·079
10	11	3·15	3·05	3·1	·052
11	10	2·60	2·60	2·6	·037
12	9	2·00	1·85	1·9	·020
13	8	1·05	1·05	1·1	·007
14	7	0·35	0·35	0·4	·001

SECTION AT 45 FEET

No. of Growth ring	Corresponding Age	Diameter D_1	Diameter D_2	Diameter Mean	Basal area
0	21	3·35	3·40	3·4	·063
1	20	3·00	3·05	3·0	·049
2	19	2·55	2·60	2·6	·037
3	18	2·10	2·10	2·1	·024
4	17	1·65	1·70	1·7	·016
5	16	1·20	1·20	1·2	·008
6	15	0·80	0·80	0·8	·004
7	14	0·50	0·40	0·5	·001
8	13	0·25	0·25	0·3	·001

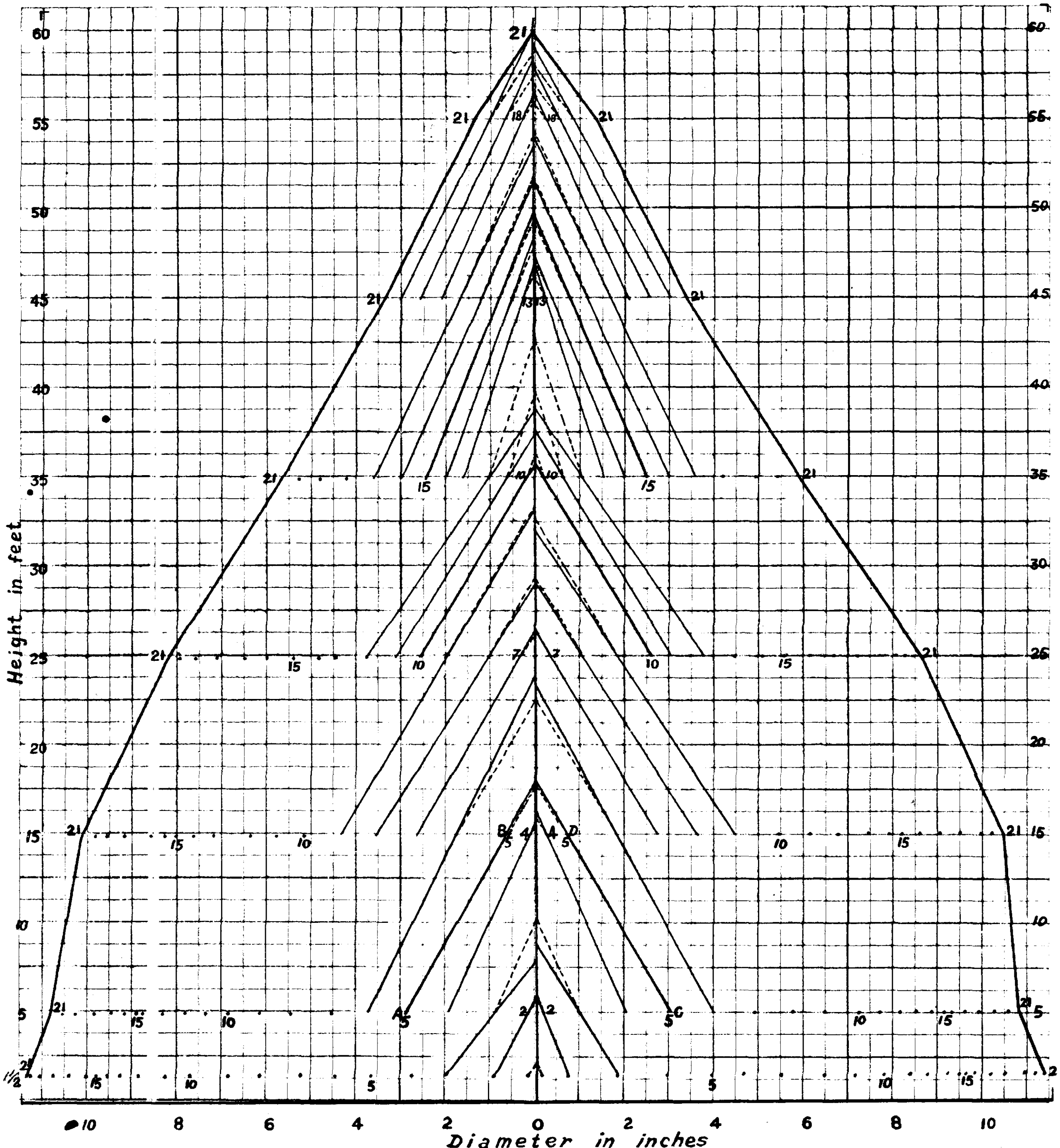
SECTION AT 55 FEET

No. of Growth ring	Corresponding Age	Diameter D_1	Diameter D_2	Diameter Mean	Basal area
0	21	1·35	1·40	1·4	·011
1	20	1·00	0·90	1·0	·006
2	19	0·65	0·60	0·6	·002
3	18	0·30	0·30	0·3	·001

Species :- Pinus longifolia

Locality:- Compound of Bungalow no. 16, F.R.I.

Diameter under Bark / Height
Curve I



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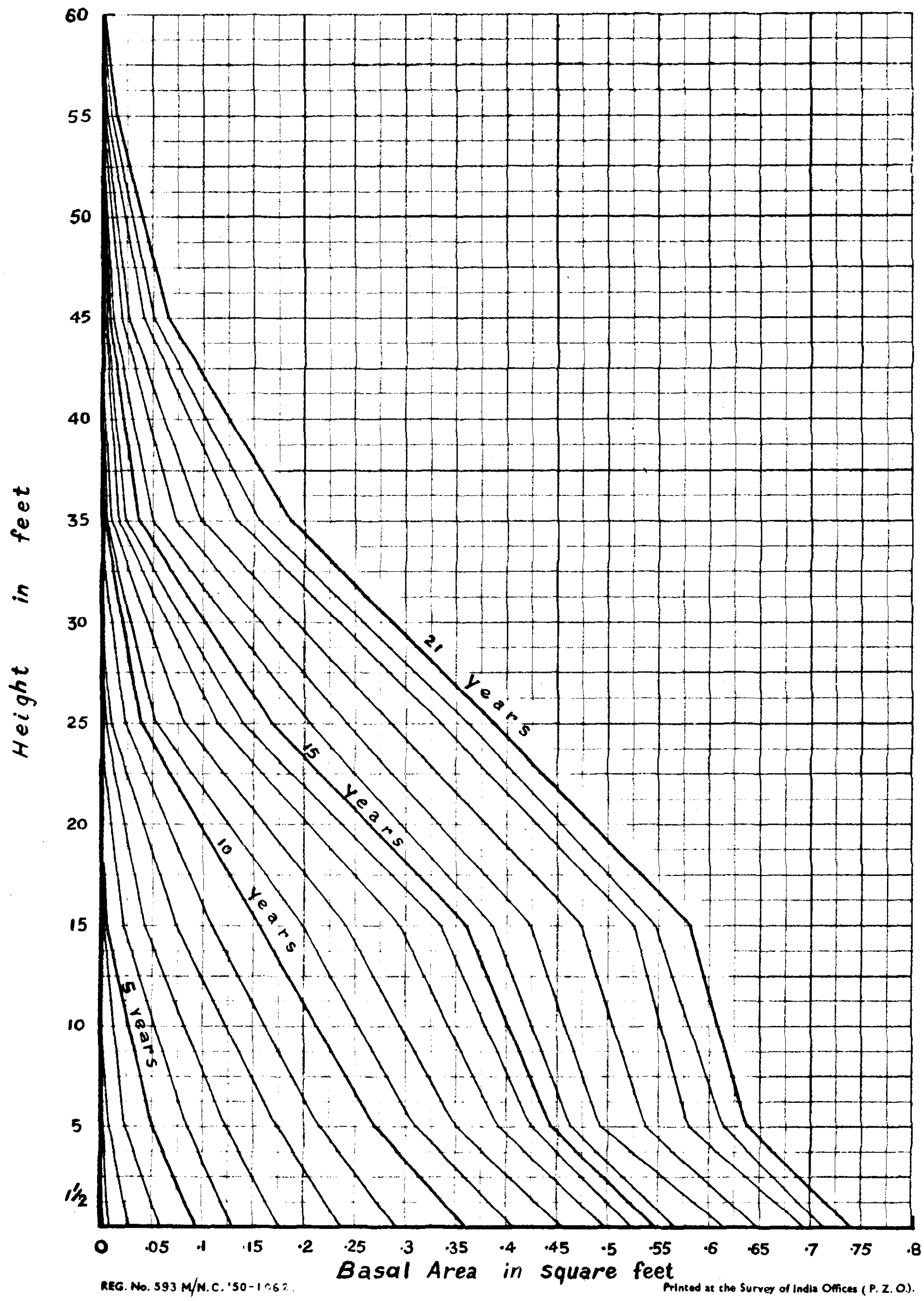
Species :- Pinus longifolia

Locality :- Compound of Bungalow no. 16, F.R.I.

Basal Area / Height
Curve II



REG. No. 593 M/N.C. '50-1062.

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APPENDIX III

Species :—*Pinus longifolia*

Locality :—Tree growing in the compound of Bungalow No. 16, F.R.I.

Heights attained at different ages

Age	HEIGHT by production	HEIGHT by drawing parallels	HEIGHT Mean	Age	HEIGHT by production	HEIGHT by drawing parallels	HEIGHT Mean
21 years ..	60 feet	60 feet	60 feet	10 years ..	36 feet	36½ feet	36 feet
20 ,, ..	59½ ,,	58½ ,,	59 ,,	9 ,, ..	32½ ,,	33 ,,	33 ,,
19 ,, ..	58 ,,	57 ,,	58 ,,	8 ,, ..	29 ,,	29½ ,,	29 ,,
18 ,, ..	56½ ,,	56 ,,	56 ,,	7 ,, ..	26½ ,,	26½ ,,	27 ,,
17 ,, ..	53½ ,,	54½ ,,	54 ,,	6 ,, ..	24 ,,	22½ ,,	23 ,,
16 ,, ..	52 ,,	52 ,,	52 ,,	5 ,, ..	18 ,,	18 ,,	18 ,,
15 ,, ..	50 ,,	49½ ,,	50 ,,	4 ,, ..	16 ,,	16 ,,	16 ,,
14 ,, ..	48 ,,	47½ ,,	48 ,,	3 ,, ..	8½ ,,	10½ ,,	9 ,,
13 ,, ..	46½ ,,	46 ,,	46 ,,	2 ,, ..	6 ,,	6 ,,	6 ,,
12 ,, ..	39 ,,	43 ,,	41 ,,	1 ,, ..	2½ ,,	..	3 ,,
11 ,, ..	37½ ,,	40 ,,	39 ,,				

THE ECOLOGY OF THE HUMUS LAYER IN SOME ENGLISH FORESTS*
PART I

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Introduction.—The distribution of typical ground flora species in oak woods of South and Midlands of England has been found by most workers, notably Salisbury (1916–18) Mukerji (1936) and Tansley (1939) to be related singly or collectively to such variable factors as light intensity, nature of the soil or its humidity.

Extensive investigations of correlation between ground flora and hydrogen ion concentration have been made by Salisbury (*loc. cit.*) in Southern England and Pearsall (1938) in Northern England. Pearsall has shown that ground flora communities are intimately related to the soil complex.

The present study aims to investigate on similar lines the relation of typical ground flora types and seedling growth to humus types in the Whippendell woods.

These woods are related to the beech forests of the Chiltern area and are developed in a deep valley and on its adjoining ridges. Four well defined forest communities, namely beech-hawthorn, ash-oak, ash-oak-hazel, and oak-birch are recognized. A detailed account of the forest vegetation has already been given (Puri, 1950*a*, *b*) and relationship between the following ground flora communities and the soil complex will now be examined.

1. *Mercurialis perennis*.
2. *Mercurialis perennis—Urtica dioca*.
3. *Brachypodium sylvaticum*.
4. *Urtica dioca*.
5. *Chamœnerion* (*Epilobium*) *angustifolium*.
6. *Scilla non-scripta—Holcus mollis—Pteridium aquilinum*.
7. *Scilla non-scripta—Rubus fruticosus* agg.
8. Bare areas.

PHYSICAL FEATURES OF THE SOIL AND TOPOGRAPHY

The major part of the vegetation studied in these woods is developed on Chalk masked by Clay-with-flints, or the Glacial Gravel. For the most part the surface deposits are fairly deep. But at one or two places, especially along steeper parts of the ridge adjoining the golf course, the Chalk is fairly close to the surface. In one or two instances it was exposed on the surface.

Topographically, the main feature of the woods is a central valley, and adjoining ridges (see Figs. 3, 4). On the side towards the golf course the slope is very steep with a gradient usually of 1 in 2 or 3. The second ridge which is gently sloping (slope 1 in 10 to 15) imperceptibly merges at its top into the central part of the woods.

The soil in the central part of the valley is generally very flinty. In a number of sites mainly where *Epilobium angustifolium* was growing, flints were so numerous that it was often impossible to collect a small soil sample. Towards the upper part of the first ridge the flints were fewer.

Along the lower part of the ridges the soil was typically of the brown earth type. On the upper part, however, surface soil was covered by a fairly thick layer of undecomposed humus, chiefly of beech leaves and fruits.

GROUND FLORA COMMUNITIES IN RELATION TO SOIL COMPLEX

A summary of the soil data for different communities is given in Table I, detailed data being presented in the Appendix.

* Contribution from the Dept. of Botany, University College, London. Part II will appear in November 1950 issue of this Journal.

TABLE 1

Soil Type	Community	pH	Thio-cyanate	Nitrate	Organic Matter	Summer Relative humidity
1	Bare areas	3·81—4·01	1—3	0—1	14·3±2·3	2·8±0·2
2	*Scilla–Rubus*	4·08—5·20	1—2	1—3	9·7±2·6	3·6±0·8
2	*Scilla–Pteridium*	4·14—5·23	1—2	1—2	8·7±2·1	3·9±1·4
2	*Chamanerion*	4·08—5·27	0—2	1—3	7·1±2·4	4·7±2·2
3	*Urtica*	5·47—8·45	0—*Ca*	2—4	6·4±3·2	5·0±1·5
3	*Brachypodium*	5·28—8·40	0—*Ca*	2—4	5·3±2·6	5·4±2·0
3	*Urtica-Mercurialis*	5·29—8·45	1—*Ca*	1—4	5·8±2·0	5·7±2·1
3	*Mercurialis*	5·25—8·45	1—*Ca*	1—4	4·8±1·8	6·1±2·6

Note :—In this investigation soil samples analysed were collected from the uniform depth of 10–12 cm. pH was determined electrometrically ; thiocyanate by Comber's test for sour soils ; Nitrate by adding Diphenylamine in concentrated sulphuric acid to clear extract of the soil. Organic matter is the loss on ignition, and Relative humidity is water content/organic matter.

On the basis of the soil properties studied, the plant communities investigated in these woods occupy three main types of soil.

Soils of Class I.—Bare areas, generally coincide with base deficient soils below pH 4·01 with very little nitrates present. There is high organic matter, nearly 15% and above 10% and a low relative humidity generally below 3. Worms were never observed in surface layers.

Soils of Class II—Scilla—Rubus, Scilla—Pteridium and *Chamænerion*, on slightly base deficient to rarely base saturated (only in *Chamænerion*) soils above pH 4·08 and below 5·27, with nitrates always present. There is moderately high organic matter, above 7% and below 10% and relative humidity generally above 3 and below 5. Worms seen.

Soils of Class III—Urtica, Brachypodium, Mercurialis and *Mercurialis-Urtica.*—On base saturated to calcareous soils, very rarely slightly base deficient, above pH 5·25, with abundant nitrates. There is low organic matter, below 7%, and high relative humidity, above 5. Worms very frequent in surface layers.

The distribution of tree seedlings in these woods seems to correspond, though very broadly, with the three classes of soil recognized above. Thus, ash and hazel are most common on soils of Class 3. Oak, hornbeam, hawthorn, beech and birch occur on soils of Class 2. Sycamore, though more common on soils of Class 2, extends to soils of Class 3 also. Seedlings of birch and beech occur on a few sites of soils of Class 1 and a few seedlings of holly were recorded only from these soils.

In a very general way the soils of Class 1 are those of beech-hawthorn community and those of Class 3 of ash-hazel or ash-oak-hazel community. Soils of Class 2 have a wide range and occur in ash-oak, oak-birch and oak-birch-sycamore communities. Some sites of Class 2 occur in recently felled areas or those which have been coppiced during the last year.

HYDROGEN ION CONCENTRATION AND DISTRIBUTION OF GROUND FLORA COMMUNITIES

In these woods, hydrogen ion concentration of the soil does not sharply differentiate between the distribution limits of different ground flora types occurring on these three classes of soil; for incidence curves for plant communities occurring on the same class of soil show a remarkable similarity (see Fig. 1).

Similar types of curves are obtained for different species of tree seedlings (Fig. 2) whose frequency curves also show overlapping. Most of the species, e.g., Birch, beech, oak, show a mode at precisely the same pH class — 4·5 to 5·0 ; modes of ash, sycamore, hornbeam, however, lie at different pH classes.

Salisbury (1921) obtained similar overlapping curves for *Scilla*, *Pteridium*, *Mercurialis*, etc., and the results obtained in this investigation agree with his facts and indicate that hydrogen ion concentration of the soil is not the only controlling factor in the distribution of these species in the South England woods.

Incidence curves for all communities studied are monomodal, showing modes at different or similar pH class. The distribution curve for *Mercurialis perennis* community (Fig. 1) does not show a second mode as was obtained by Salisbury (cf. *loc. cit.*, Fig. 5). In this it agrees with the data given by Pearsall (1912) for this community in the North England woods and with that obtained by Olsen (1923).

It thus, appears, that the effects of pH constitute only one of those factors associated with the complex of soil conditions that control the distribution of ground flora communities in these woods.

In the area studied pH differences are associated with topography and other soil differences (Fig. 4). Usually the communities with a low pH generally tend to occur on upper part of the ridge or on level topography in the extreme centre of the valley (Fig. 3). Those with a high pH are characteristic of small depressions or lower parts of the ridges. This feature of plant distribution is associated with soil conditions (Fig. 4). There is generally an increase in soil pH from the upper to the lower parts along this slope and in the centre of the valley it is generally low. In this the soils in the valley resemble those on the top of the ridge.

Salisbury (1922) also obtained low pH values for the surface soil in upper parts of the beechwoods on Chalk and samples from the lower slopes showed high pH.

Lutz and Chandler (1946) maintain that pH values of the soil generally decrease with an increase in elevation.

Soils on the upper parts of the ridges are usually base deficient, while those along the lower slopes are less base deficient or more base saturated. This may be due partly to constant leaching of calcium salts, which according to Salisbury (*loc. cit.*) is more intense on higher slopes. Thus, the top-soils generally tend to become more base deficient or sour. The flushing effects along lower slopes, however, maintain the level of calcium salts and these generally remain base saturated. In the central flat parts of the valley the loss due to leaching is not made up by flushes so that these soils also become base deficient.

The relation between base deficiency of the soil and its acidity is seen in Fig. 5.

Approx. pH $3 \cdot 81 - 3 \cdot 95 = \frac{3}{4}$ of soil bases are leached out of the soil.

,, pH $3 \cdot 96 - 4 \cdot 50 = \frac{1}{2}$ of soil bases are leached out of the soil.

,, pH $4 \cdot 60 - 5 \cdot 20 = \frac{1}{4}$ of the soil bases are leached out of the soil.

,, pH $5 \cdot 30 - 6 \cdot 50$ = soil is usually base saturated.

above approx. pH $6 \cdot 85$ = soil is generally calcareous.

It follows that soils on upper parts of the ridges are both base deficient and acidic.

Soil acidity at higher slopes may be due to low relative humidity of these soils; for relative humidity on higher parts of the slope is low and a more or less increasing gradient in R.H. values is seen from the upper to the lower samples along a transect and with an increase in relative humidity there is a tendency towards an increase in pH value of the soil (Fig. 6).

The drying of soils with high organic content lowers pH, but those with low organic content do not become acidic on drying, as is shown in Tables 2, 3.

Table 2.—Changes in pH on drying soils of high organic content from Oxshott (organic matter 45·6%—48·5%).

Sample No.	Initial pH	After 24 hours	After 48 hours	After 96 hours
1	3·47	3·46	3·38	3·15
2	3·58	3·56	3·45	3·22
3	3·57	3·44	3·48	3·40
4	3·74	3·49	3·52	3·31

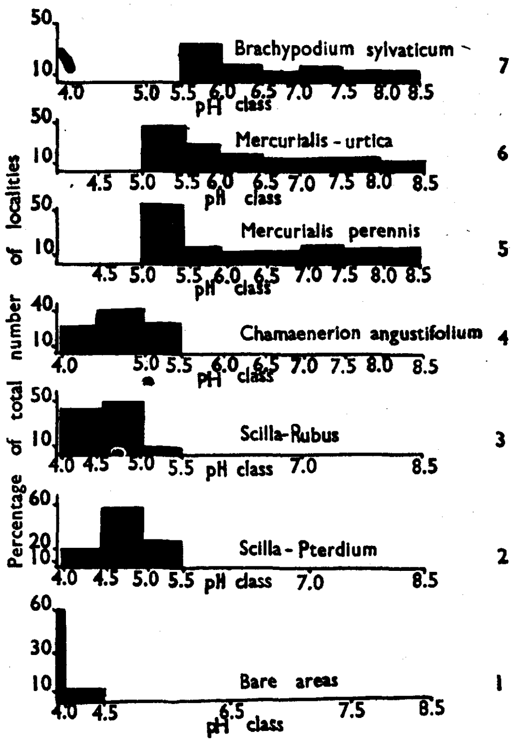


Fig. 1

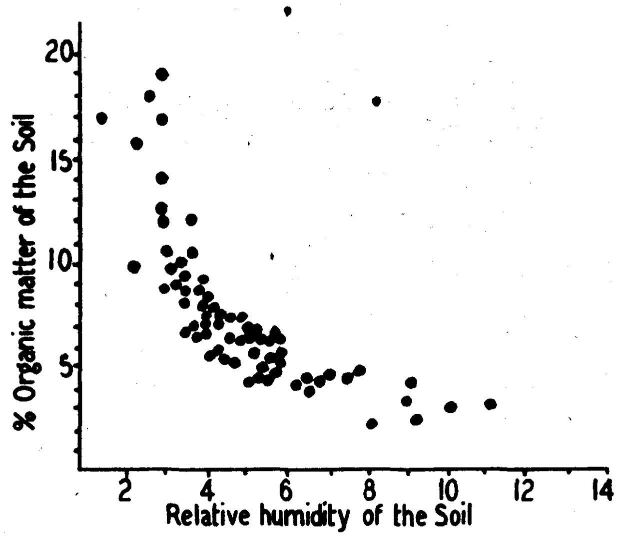


Fig. 8

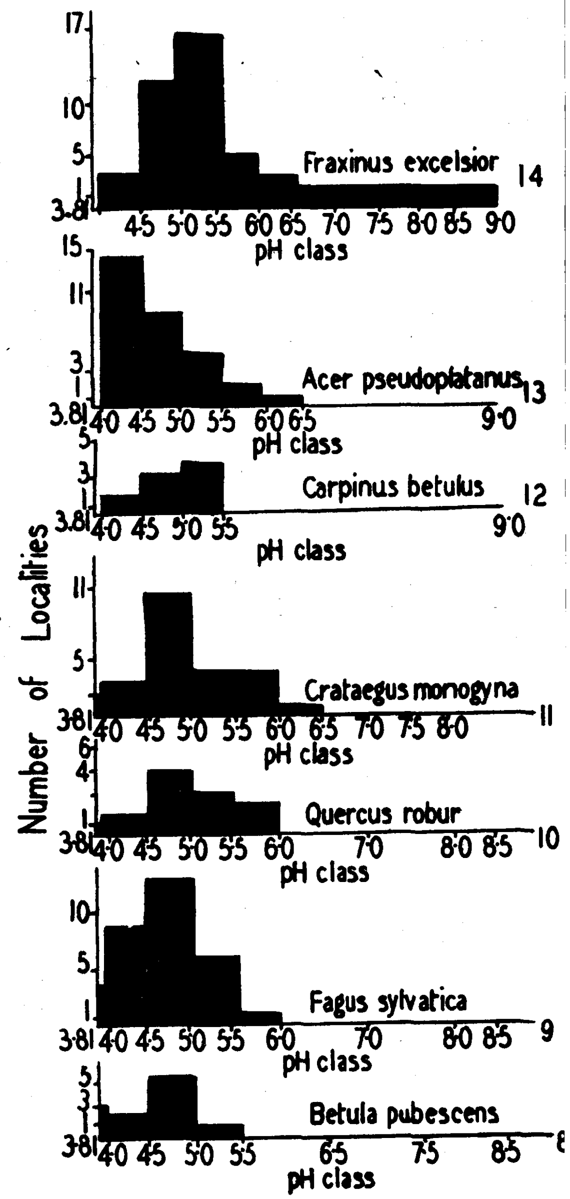


Fig. 2

Fig. 6

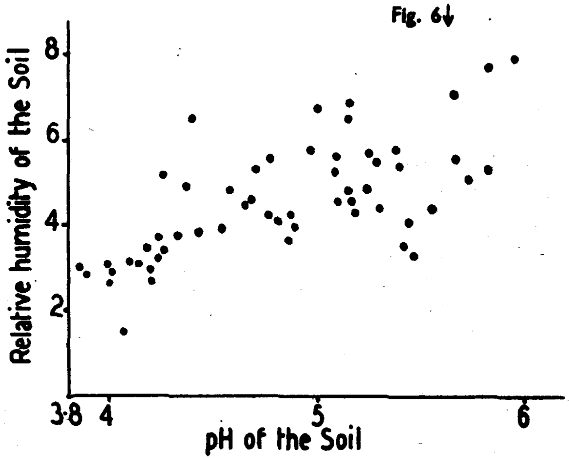
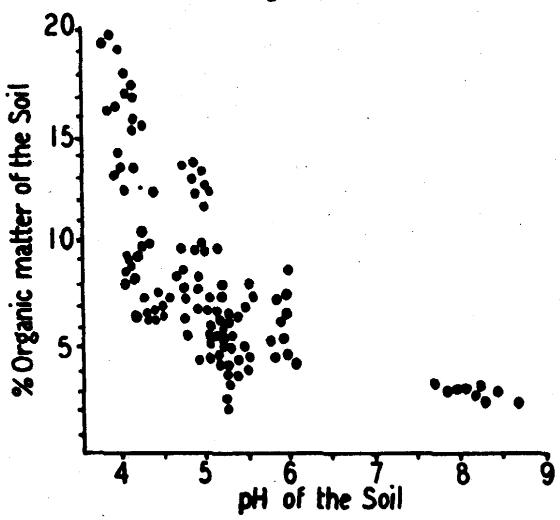


Fig. 7



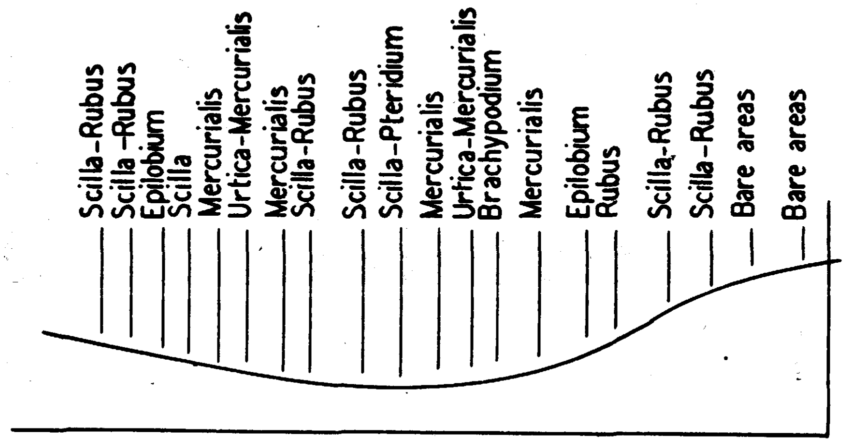


Fig. 3

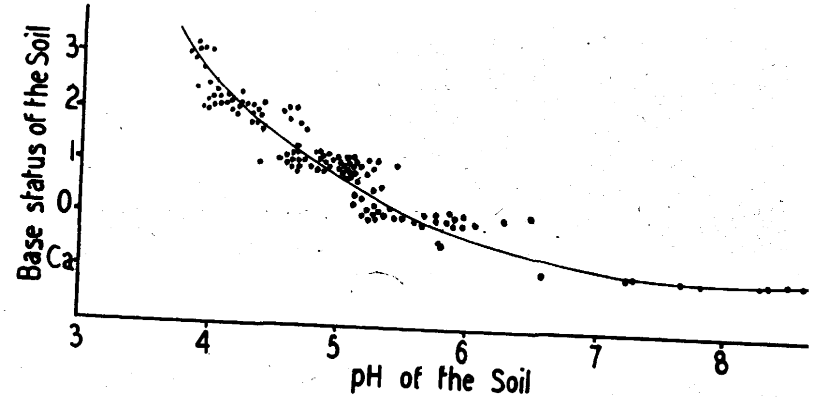


Fig. 5

Fig. 4

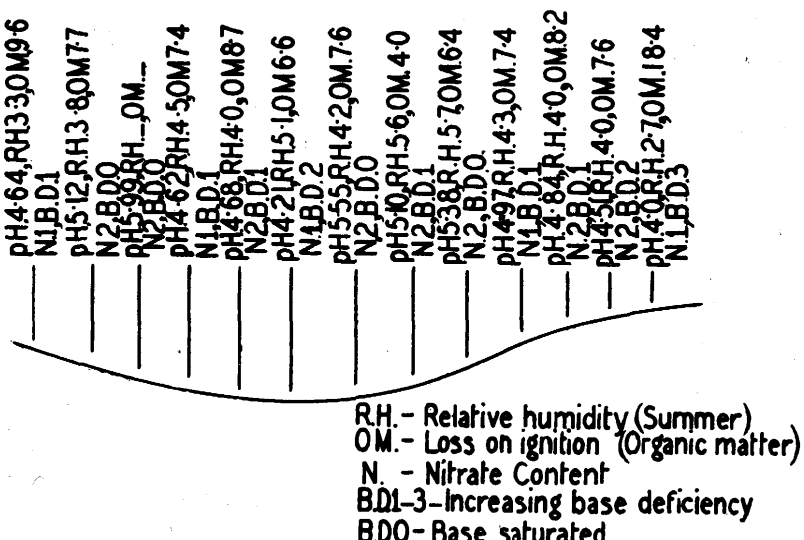


Fig. 9

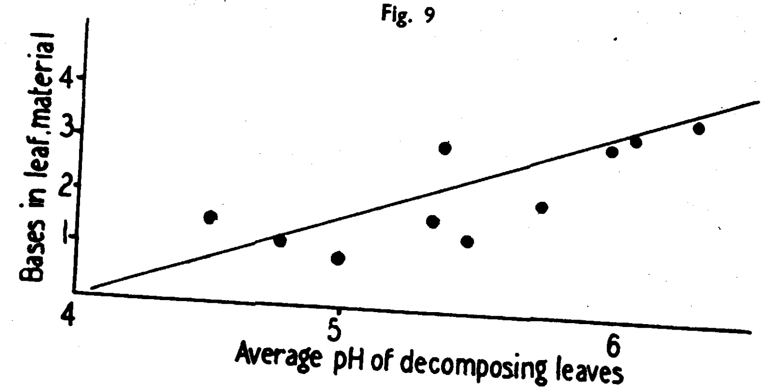


Table 3.—Changes in pH on drying soils of low organic content from the Whippendell woods.

Sample No.	Initial pH	After 24 hours	After 48 hours	After 72 hours	After 96 hours
1	5·51	5·71	5·92	5·95	5·97
2	6·21	6·20	6·51	..	..
3	7·20	7·60	7·83	7·88	..
4	8·42	8·54	8·66	8·62	..

It will be noted that drying of soils of low organic content results in a rise of soil pH.

This agrees with the results obtained by Pearsall (1938) showing that the effect of drying on different type of soils is different.

Bailey (1931) has stated that the drying of soil decreases pH, but he does not indicate the type of soil he used in his experiments.

Addition of water reduces hydrogen ion concentration by dilution and every addition of 10 c.c. of distilled water to air dried (for 48 hours) samples increases one unit of pH.

The organic matter in the soil is another factor which seems to promote soil acidity. Soils on the higher slopes are usually high in organic content, the percentage of which seems to decrease from the higher to the lower slopes along a transect. In the centre of the valley, it is again high. With an increase in organic content there follows generally a more or less proportional rise in soil acidity (Fig. 7). The most interesting feature of the data, however, is that while the less organic forest floor has a high pH, in the more organic soil pH range does not necessarily become low in proportion. It still tends to remain high with an increase of organic matter. This is related with the chemical composition of the organic matter and the activities of worms.

These results agree essentially with Salisbury's (*loc. cit.*) facts.

Although precise relationship will be influenced by the base content of the forest litter, the present data, however, seems to suggest that communities with low pH generally occur in soil with a high organic content. The communities characteristic of high pH, on the other hand, usually occupy soils of low organic content.

From the above considerations, it may be permissible to conclude that the hydrogen ion concentration of the soil is only one of the group of factors delimiting the distribution of ground flora types occurring on the three types of soil in the Whippendell woods.

ORGANIC MATTER OF THE SOIL

The chief source of soil organic matter is the tree litter, that becomes available annually during autumnal leaf-fall. During the autumn of 1946 estimates were made of the amount of litter falling on soil with different ground flora types. In these estimates the ground flora species chiefly *Epilobium* and *Pteridium* were also included besides leaves, twigs, fruits and cones of trees. The amounts received by soils of the three main classes is given in Table 4.

Table 4.—Average amount in gms. of air dry plant material gained by one square meter area in the Whippendell woods in autumn of 1946.

Soil Type	Community	No. of sites	Average amt. in gms. ± st. Deviation	Average for soil class
1	Bare areas	8	2385±243·2	**2385 ±243·2**
3	*Mercurialis*	8	1902±295·6	
3	*Brachypodium*	8	1601±380·8	**1676·6±302·6**
3	*Mercurialis-Urtica*	4	1480±231·5	
2	*Scilla–Rubus*	8	**1593±284·0**	
2	*Scilla–Pteridium*	8	1440±231·5	**1453 ±256·0**
2	*Chamænerion*	8	1327±255·1	

The average amount of litter gained by soil for all sites per square meter area in these woods was 1828 ± 268 gms., a figure at least 300 gms. higher than that obtained by Pearsall (1945) for oak woods of Hertfordshire. Pearsall's estimations did not include ground flora species.

In the Whippendell woods, the highest amount was gained by soils of Class 1. Most sites of this class were situated under mature beech, which on an average were nearly 150–200 years old.

The soils of Class 2 were mostly situated in open places or under well spaced mature oak, ash, hornbeam, birch, sycamore, or pine, some of which may on an average be well above 80 years old.

Tree vegetation over soils of Class 3 was mostly standards or saplings of ash, sycamore, cherry, oak, beech or these sites were situated under coppiced plants of hazel. Most of these plants were generally 35–50 years old.

Thus, it follows that the amounts of forest litter gained by soils of different classes would depend upon the age of tree vegetation, its density, size and species of individual trees. It may, therefore, be envisaged that the amount of organic matter gained by soils of Class 1 for a long term average would be greater than those gained by soils of Class 2 and 3.

Twigs and branches constitute nearly half of the total amount of litter. Leaves/twigs ratio for soils of Class 1 is 2·2 and it is 1·7 for soils of Class 2. In soils of Class 3 this ratio is the highest. It was observed that leaves usually decompose quicker than twigs, so this ratio assumes some importance in the decomposition of forest litter.

TABLE 5

Soil class	No. of sites	Average air dry wt. in gms. of leaves per one sq. met. area	Average air dry wt. in gms. of twigs and branches per 1 sq. met. area	Leaves/twigs
1	8	1582	703·3	2·2
2	24	804	451·7	1·7
3	20	1234	479·5	2·5

Note :—Ground flora species and fruits, seeds, etc., included in Table 4 are not included in this Table.

FOREST LITTER AND WORMS

In soils of Class 1 worms are usually not observed in surface layers, but they are most abundant in soils of Class 3 in these woods.

Bournebusch's (1930) data on the occurrence of worms in Danish forests reveals that out of 11 species found in these soils 8 occurred in *Mercurialis* community developed on mull soils under oak. In beech-*Oxalis* mull soils he recorded 6 species. Worms were very rare in beech raw humus and spruce raw humus.

The absence of worms from surface layers in soils of Class 1 may be partly due to low relative humidity, as worms are usually absent from surface layers if relative humidity is below 3, Table 6.

TABLE 6

Samples (at 10 cm. depth) on which worms were observed in the Whippendell woods.

Relative humidity class	Below 3	3–5	5–6	6–7	Above 7
No. of sites on which worms were observed	0	13	7	3	2
% of total records for each class ..	0	52	28	12	8

It is generally understood that in dry soils worms go into deeper layers. Lutz and Chandler (1946) have stated that during winter and dry months worms descend to lower horizons.

Relation between worms and the soil organic matter is given in Table 7, showing that worms are more obvious in surface layers of the soil whose organic matter is between 3%–8%. Above 8% they are greatly decreased and were not seen in surface layers of the soil whose organic matter was above 10%.

Table 7.—Percentage organic matter of soils (at 10 cm. depth) on which worms have been observed in these woods.

% Organic matter class	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	Above 10
No. of sites ..	3	4	4	4	4	4	1	1	0
% of total No. of sites ..	12	16	16	16	16	16	4	4	0

Soil acidity seems to influence the occurrence of worms which are not obvious in soils whose pH lies between 5·0–5·5 (Table 8). Below pH 4·50 worms have not been observed in surface layers in these woods. Alkalinity does not seem to restrict their presence, though they are less obvious in highly alkaline soils.

Table 8.—pH of soils (at 10 cm. depth) on which worms have been observed in the Whippendell woods.

pH class	3·81–4·0	4·01–4·5	4·51–5·0	5·01–5·5	5·51–6·0	6·01–6·5
No. of sites ..	0	0	4	21	8	2
% of total No. of sites ..	0	0	8·6	43·4	17·2	4
pH class	6·51–7·0	7·01–7·50	7·51–8·0	8·01–		
No. of sites ..	2	3	3	3		
% of total No. of sites ..	4	6·5	6·5	6·5		

Observations of Salisbury (1924), Wherry (1924), Waksman (1932), etc., on this point agree with my results and it seems that worms occur in soils between pH 5·0 and 8·0.

Ramann (1911) and his co-workers have stated on experimental evidence that worms could live in acid soils. The absence of worms from mor soils according to them was due to low moisture content.

Data presented in Table 9 indicates that worms are usually not observed in surface layers of highly base deficient soils. They are most obvious in base saturated or in slightly base deficient soils.

Table 9.—Base status of soil (at 10 cm. depth) on which worms have been observed in the Whippendell woods.

Base status of the soil	Cal-careous	Base saturated	Base deficient 1	Base deficient 2	Base deficient 3 & 4
Number of sites where worms were found ..	11	15	12	2	0
% of the total No. of sites	22	30	24	4	0

From the above it appears that the absence of worms in surface layers of soils of Class 1 and their occurrence in those of Class 2 is associated with low relative humidity, high organic matter, low pH and low base status of the soil. High relative humidity, low content of organic matter, high pH, and high base status, on the other hand, seems to be related to their abundance in soils of Class 3.

Millar and Turk (1946) state that worms occur in moist places with an abundance of organic content and available calcium ; their numbers in sandy soils of low organic matter and acid reaction is very small.

No data as to the number or weight of worms in a unit area or volume of soil could be collected in this investigation. But Dr. C. A. Evans of Rothamstead tells me that there are 200–1500 lb. of worms in one acre area in pasture land (Rothamstead) and their weight in woodland soils may easily be between 200–1000 lb. per acre.

In clayey loams of Oregon, Powers and Bollen (1935) found that the number of worms per acre was 2,50,000. Eaton and Chandler (1942) gave the figures of approximately 5,22,000 to 1·0,10,000 worms per acre in coarse mull soils of New York.

According to Lindquist (1938) the average of worms per square meter area in mixed hardwoods of Sweden is 150.

From these examples, it would be easy to visualize that this large population of worms would exercise a considerable pressure on forest litter, which is their main source of food.

In laboratory experiments conducted by me at the University College, worms showed a preference for leaves of ash, cherry, willow, hazel, lime and birch. They definitely avoided leaves of beech, chestnut, hawthorn, and unless forced to starve they perhaps would not nibble them. They seem to consume leaves of oak, sycamore, hornbeam to some extent but in presence of ash, cherry or lime they leave them untouched. Pine needles, bracken, or mosses (*Polytrichum* and *Dicranum*) were not acceptable probably.

Darwin (1881) has stated that worms preferred cherry to lime and hazel and gnawed petioles of *Clematis* and twigs, but pine needles were not nibbled.

On the evidence of Johnston, Gast (1937) mentioned that leaves of *Populus grandidentata*, white ash, and bass wood are among the favourite food of *Lumbricus terrestris*. Leaves of sugar maple and red maple are accepted less readily, but leaves of *Quercus borealis* are not eaten.

It has not been possible to estimate the amounts of litter that worms consume in a given time. Bassalihr (1912) has, however, stated that worms consume about $\frac{1}{16} - \frac{1}{4}$ of the total litter production in a beech wood ; thus it seems that worms are mostly responsible for clearing the forest floor of a large amount of litter from soils of Class 3. In soils of Class 1 and 2, on the other hand, litter of beech, hawthorn, chestnut pine and oak would remain largely untouched. In this way the ratio of plant material between soils of Class 1 and 3 and of Class 2 and 3 would be increased by the activities of worms.

In addition to bringing about a considerable decrease in the amount of litter in soils of Class 3 worms decrease soil acidity. Darwin (1881) was the first to point out that worm casts are less acidic in reaction than surface soils.

Salisbury's (*loc. cit.*) results show that in more acid soils pH of worm casts was higher ; in alkaline samples, however, pH of casts was not higher than that of the surrounding soil, but was usually lower.

The results obtained in this investigation seems to show that pH of worm casts is always higher than that of the soil on which worms were feeding (Table 10). In a soil of low pH the difference between pH of the casts and the soil is generally higher but when the soil is of a high pH the difference is of a smaller degree.

The interesting feature that emerges from the data is that when worms are feeding on leaves of ash, cherry, hazel, lime, the reaction of casts is more alkaline than that of the adjacent soil but when they are not feeding on leaves and are feeding only on the soil the reaction is higher though the difference between pH of casts and that of the soil in this case is smaller.

Table 10.—pH of soil and casts of worms kept in laboratory.

Soil		Worm Casts		Difference in pH	Worms feeding on
No. of samples	Av. pH	No. of samples	Av. pH		
2	5·90	14	7·28	1·38	ash, cherry.
4	5·62	15	7·06	1·44	ash, hazel.
2	7·03	11	7·68	0·65	only soil (Beech)*.
1	7·20	10	7·85	0·65	Only soil (Chestnut)*.

* Leaves not being eaten.

Worm casts not only show a higher pH than the adjacent soil but, as pointed out by Darwin and Salisbury, they have a higher percentage of organic matter. The most interesting feature of the organic matter data obtained in this investigation is that with an increase in organic content from soil to worm casts there is no increase in acidity of the casts. On the other hand, with an increase in organic matter there is a tendency in some cases towards an increase of pH.

Lunt and Jacobson (1944) have shown that worm casts from hardwood forests are richer

in exchangeable and total calcium, and base saturated, and have a higher pH than the adjacent soil.

The favourite food of worms is rich in bases (calcium) ; and when worms are not feeding on base rich leaves the reaction of the casts is less alkaline. Thus it may seem that high base status of the worm casts is due partly to high amount of bases in the leaves they eat.

Muller (1886) has suggested that mull soils of Danish deciduous forests are largely due to the activeties of earth-worms.

DECOMPOSITION OF FOREST LITTER

From general observations just described it appeared that the decomposition of plant material in field was most rapid in soils of Class 3. The presence in early summer of large amounts of slightly decomposed or almost fresh litter on most sites of soils of Class 1 and 2 seemed to suggest that this was probably due to the slower decomposition at these places.

The decomposition of litter in nature is influenced by base status of the soil, its moisture content, suitable temperature and chemical composition of the plant material.

The soils of Class 3 are generally base saturated, or often calcareous with a high relative humidity. The soils of Class 1 and 2 on the other hand, are always more base deficient and have a low relative humidity. The early decomposition of litter in soils of Class 3, therefore, may be partly due to these soil properties. This is evident from Fig. 8. It appears that with a decrease in relative humidity in these soils the accumulation of humus is generally increased.

Waksman (1938); and Lutz and Chandler (*loc. cit.*) have shown that the decomposition of plant material is most rapid in soils rich in calcium. Base deficiency in soils tends to retard decomposition and favours humus formation. The percentage of organic matter and base deficiency of soil plotted in Fig. 10 shows that the accumulation of organic matter generally increases with an increase in base deficiency in these soils.

More detailed field observations, however, revealed that on all sites of soils of Class 3, which had more or less similar properties, the litter of different tree species was being decomposed with the same rapidity. In a mixed litter leaves of ash, cherry, lime, hazel, sycamore, etc., seemed to disappear earlier than those of beech, chestnut, oak, pine, spruce, hornbeam, etc. This is evidently due to the chemical composition of the plant material.

CHEMICAL COMPOSITION OF THE LITTER AND ITS DECOMPOSITION

In connection with the above study an attempt was made to obtain additional information about the character of the dry leaf material from different trees. The results are introduced in Tables 11 to 14. According to Waksman (*loc. cit.*) the water soluble substances are the first chemical constituents to be attacked by micro-organism. In Table 11 are given the figures for substances in leaves of different species which are soluble in cold and hot water respectively.

Table 11.—Approximate amounts of water soluble constituents in mature dead leaves of different trees (on per cent of dry material).

Species	Cold water solubles	Hot water solubles	Total	Cold/Hot water solubles
Fraxinus excelsior ..	21·6	6·4	28·0	3·3
Prunus padus ..	20·3	6·1	26·0	3·3
Corylus avellana ..	16·5	4·8	21·3	3·4
Acer pseudoplatanus	16·1	10·1	26·2	1·0
Carpinus betulus ..	15·8	6·6	22·4	2·4
Betula pubescens ..	14·8	9·2	24·0	1·6
Aesculus hippocastanum ..	13·8	7·2	21·0	1·9
Quercus robur ..	9·1	8·3	17·4	1·0
Castanea sativa ..	8·0	10·0	18·0	0·8
Fagus sylvatica ..	7·2	6·1	13·3	1·1
Pinus sylvestris ..	4·0	3·8	7·8	0·5

It will be seen that fast decaying species, e.g., ash, cherry, hazel, etc., are rich in water soluble substances. The ratio of cold : hot water soluble substances is usually high in these species. In Beech, chestnut, pine, etc., it is low. It will be shown in the next table that species with a high ratio of cold : hot

water soluble fraction are usually rich in ash and bases.

Data for ash, carbon and bases in leaves for a few species are given in Table 12.

TABLE 12

Species	Ash on % dry weight	Carbon on % dry weight*	Bases (as CaO) on % dry weight
Tilia cordifolia ..	10·45	47·2	4·38
Fraxinus excelsior ..	8·43	48·3	3·38
Acer pseudoplatanus ..	8·07	48·6	2·56
Prunus padus ..	7·91	48·6	3·56
Cratægus monogyna ..	7·55	48·8	3·01
Corylus avellana ..	7·40	48·9	3·16
Aesculus hippocastanum ..	7·13	49·1	3·16
Carpinus betulus ..	6·03	49·6	1·55
Fagus sylvatica ..	5·68	49·5	1·91
Quercus robur ..	4·76	50·3	1·78
Taxus baccate ..	3·76	50·8	0·98
Betula pubescens ..	2·91	51·3	1·18
Pinus sylvestris ..	2·91	51·3	0·78
Castanea sativa ..	2·57	51·4	1·13

(The figures are averages of three determinations).

* Determined by dividing loss on ignition by 1·95 as suggested by Waksman (1938) for fresh leaf litter.

The species investigated fall into 3 main groups :—

1. *Birch, pine, chestnut.*—Ash below 4%, bases usually about 1%, carbon usually more than 50%. Seedlings of these species generally predominate on more base deficient soils with pH values approximating to 4. The small amounts of bases brought to the surface of the soil in the litter of these species do not make good the loss of bases due to leaching. These are non-exacting on soil bases.

2. *Oak, beech, hornbeam.*—Ash usually above 2%, carbon generally between 49–50%. Seedlings of these species generally occur in less base deficient to slightly base saturated soils of pH usually above 4. The bases brought on the surface do not generally replenish the loss against leaching if they are occurring on lime-poor soils.

3. *Ash, cherry, lime, sycamore, horse chestnut.*—Ash above 7%, bases above 2%, carbon usually between 47–49%. Seedlings of these species generally occur in base saturated to calcareous soils with pH above 5 (exceptions in sycamore). The amount of bases brought on the surface is generally sufficient to maintain the high base status of the soil. These are exacting on soil bases.

From the above considerations it seems that :—

1. Species which are absent from poor soils are usually rich in water soluble substances, have a high ash content, high bases and a low c/ash ratio. These are most readily eaten by worms.

2. Species with slow decomposing litter, on the other hand, occur on poor soils of Class 1 and 2, and are poor in water soluble substances, have a low ash content, low bases and a high c/ash ratio. Most of these are not eaten by worms.

3. Bases in litter seem to be effective to some extent in neutralizing acidity produced in soil during decomposition of the plant material.

Data recording pH changes during laboratory decomposition in soil of powdered leaf material of a few species is summarized in Table 13.

Average pH data from this Table are plotted against percentage bases in Fig. 9. It appears that the decomposing plant matter of species rich in water soluble bases has usually a higher pH than that of species which are poor in bases.

Table 13.—pH of powdered leaves in soil during decomposition.

Species	Range of pH	Mean
Prunus padus	*5·52–7·65†	6·28
Fraxinus excelsior	5·10–7·65	6·04
Fagus sylvatica	4·74–6·82	5·70
Aesculus hippocastanum ..	4·72–7·54	5·97
Quercus robur	4·69–6·18	5·30
Betula pubescens	4·49–6·93	5·47
Acer pseudoplatanus ..	4·47–7·06	5·70
Corylus avellana	4·30–6·97	5·31
Pinus sylvestris	4·26–5·88	4·96
Castanea sativa	4·02–5·87	4·73
Carpinus betulus	3·67–5·94	4·46

* These determinations were made after the material has decomposed for 23 days. The last readings † were got after 74 days of the first reading. The experiment thus [illegible] for 97 days.

Stepanov (cf. Jenny, *loc. cit.*) has shown that pH of leachate from decomposing plant material is proportional to the CaO plus MgO content of the species.

Nitrogen of the litter is shown by Waksman (*loc. cit.*) and Watson (1930) to influence the rate of decomposition. Data for Carbon, Nitrogen and C : N for some species is summarized in Table 14.

Table 14.—Carbon, Nitrogen and C : N in leaves of a few species*.

Species	Nitrogen on % dry weight	Carbon on % dry weight	C : N
Corylus avellana ..	2·38	48·6	20·7
Prunus padus ..	2·34	48·8	20·8
Quercus robur ..	2·35	50·5	21·0
Tilia cordifolia ..	2·17	47·0	21·1
Acer pseudoplatanus ..	2·28	48·6	21·3
Fraxinus excelsior ..	1·67	48·2	22·2
Fagus sylvatica ..	1·68	50·0	29·7
Betula pubescens ..	1·67	51·4	30·8
Cratægus monogyna ..	1·49	49·2	32·8
Castanea sativa ..	1·55	51·4	32·9
Pinus sylvestris ..	1·24	51·3	41·2
Carpinus betulus ..	1·13	49·6	43·4

Note :—* Averages of three determinations.

On the basis of C : N data the species investigated fall into three broad groups :

1. *Hazel, cherry, sycamore, lime, ash, oak.*—C : N between 20–22. These species with the exception of oak and sycamore were more readily eaten by worms and also decomposed more readily in the woods.

2. *Beech, birch, hawthorn, chestnut.*—C : N between 29–33. These species, excepting birch, were not eaten by worms and decomposed slowly in the woods.

3. *Hornbeam and pine.*—C : N above 40. These species were neither eaten by worms nor decomposed in the woods.

Species under Group 1, usually occur on soils of Class 2 and 3, high nitrate content of these soils is due to low C : N ratio of their litter. Species of Group 2 and 3 usually occur on soils of Class 1 which are poor in nitrates. As C : N of the litter influences its rate of decomposition and the availability of nitrates in the soil, it would also influence the accumulation of organic matter in the soil. The accumulation of organic matter in these woods seems to run parallel with the decrease in nitrate content of the soil.

It will be noted that pre-vernal and vernal species usually predominates in these woods on soils of Class 3. While summer species are found on soils of Class 2. On soils of Class 1, there is no vegetation in early summer but some plants may spring up in late summer. This relation of species to soil types may be due to the availability of nitrates in these woods.

(*To be continued*)

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART III

(*Continued from the* "Indian Forester", *September 1950*, *page 394*)

Alternate design of a 20 feet span bridge :—

Width of Bridge 10 feet to take I.R.C. 'B' class loading, timber used being sal (*Shorea Robusta*) ; grade of timber being structural No. 2 conforming to standard grade.

Design of Decking :—

Spacing of roadbearers is as shown in Fig. 22.

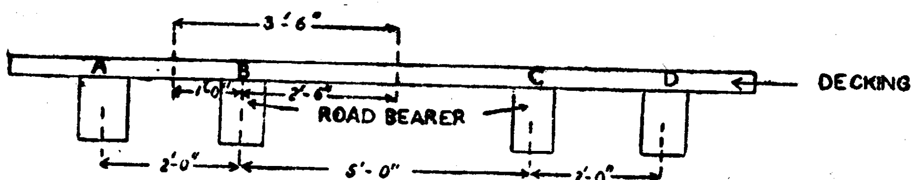


FIG 22

(1) Consider 12" width of plank and span BC = 5 feet.

(2) U.D.D.L. due to 0·453 ton per linear foot of each traffic lane on a span of 5 feet is

$$W_1 = \frac{0\cdot453 \times 2240}{10} \times \frac{5}{1} = 507 \text{ lb.}$$

(3) Dead weight of decking itself of 5 feet length, 12" width and say 4" thick is

$$W_2 = \frac{5}{1} \times \frac{12}{12} \times \frac{4}{12} \times \frac{60}{1} = 100 \text{ lb.}$$

Considering prolong duration of dead loading we have

$$W_2 = 2 \times 100 = 200 \text{ lb.}$$

(4) $W_1 + W_2 = 507 + 200 = 707$ lb.

(5) B.M._{max} due to (4) $= \frac{WL}{12} = \frac{707 \times (5 \times 12)}{12}$

$= 3535$ in lb.

(6) U.D.D.L. due to 6 tons knife-edge load per foot run of each traffic lane over span BC = 5 feet is

$$W = \frac{6 \times 2240}{10} \times \frac{5}{1} = 6720 \text{ lb.}$$

(7) B.M._{max} due to (6) $= \frac{WL}{12} = \frac{6720 \times (5 \times 12)}{12}$

$= 33600$ in lb.

(8) Total max. B.M. due to (5) and (7) is $3535 + 33600 = 37135$ in lb.

(9) Now B.M. = f z (By simplified theory)

where B.M. = Bending moment

f = Extreme fibre stress

z = Modulus of section

$= \frac{bd^2}{6}$ for rectangular beam sect.

$$\therefore\ 37135 = 2400 \times \frac{bd^2}{6}$$

$$\therefore\ d^2 = \frac{37135}{2400} \times \frac{6}{12} \text{ where } b = 12'' \text{ assumed}$$

$$\therefore\ d^2 = 7 \cdot 8$$

$$\therefore\ d = 2 \cdot 79$$

$$\therefore\ d = 3 \text{ inches (approx.)}$$

Use main decking of 3″ thickness and over it at right angles place planks 1½ inch thick nailed down to main decking to take wear and tear of traffic.

Tests of Decking against Shear :—

As per previous calculations in Part I for 15 feet span bridge it will be observed that thickness of decking is safe against shear.

Test of Decking against Deflection :—

(1) Allowable deflection $= \frac{1}{240}$ th of span.

$$= \frac{1}{240} \times 5 \times 12 \text{ in.}$$

$$= 0 \cdot 25 \text{ inch.}$$

(2) Now actual deflection of the decking is due to

δ_1—On account of 0·453 ton per linear foot of each traffic lane. (Uniformly distributed).

δ_2—On account of 6 tons due to knife-edge load per traffic lane. (Uniformly distributed).

δ_3—On account of 3 times the dead load due to material of decking. (Uniformly distributed).

(3) The deflection is given by

$$\delta = \frac{5}{384}\ \frac{WL^3}{EI} \text{ for uniformly distributed load.}$$

(4) $\therefore\ \delta_1 + \delta_2 + \delta_3$ is given by $\frac{5}{384}\ \frac{WL^3}{EI}$

$$\begin{aligned} \text{where}\quad W &= 507 + 6720 + 3 \times 100 \text{ lb.} \\ &= 507 + 6720 + 300 = 7527 \text{ lb.} \\ L &= 5 \text{ feet} \\ E &= 2 \times 10^6 \text{ lb./sq. in.} \\ I &= \frac{bd^3}{12} = \frac{12 \times (4 \cdot 5)^3}{12} = (4 \cdot 5)^3 \text{ in.}^4 \end{aligned}$$

$$\therefore\ \delta_1 + \delta_2 + \delta_3 = \frac{5}{384} \times \frac{7527 \times (5 \times 12)^3}{2 \times 10^6 \times 4 \cdot 5^3} \text{ in.}$$

$$= 0 \cdot 116 \text{ inch.}$$

(5) Since the actual deflection is less than the allowable deflection, the design of decking is safe against deflection.

Design of Roadbearers :—(See Fig. 23).

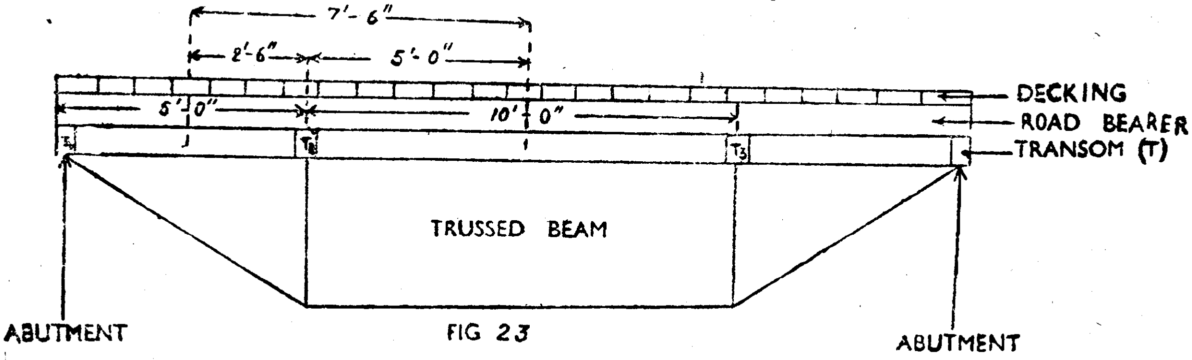


FIG 23

(1) U.D.D.L. due to 0·453 ton per linear foot of each traffic lane over 10 feet span (Fig. 23) and (1 + 2·5) feet, i.e., 3·5 feet width (Fig. 22) is

$$W_1 = \frac{0\cdot453 \times 2240}{10} \times \frac{(10 \times 3\cdot5)}{1} = 3552 \text{ lb.}$$

(2) Dead weight of decking $= 10 \dfrac{4\cdot5}{12} \times \dfrac{3\cdot5}{1} \times \dfrac{60}{1} = 788$ lb. coming over one roadbearer.

$\therefore W_2 = 2 \times 788$ considering prolong duration of dead loads.
$\therefore W_2 = 1576$ lb.

(3) Dead weight of one roadbearer assuming it to be $10'' \times 4''$ section

$$= \frac{10}{1} \times \frac{10}{12} \times \frac{4}{12} \times \frac{60}{1} = 167 \text{ lb.}$$

$\therefore W_3 = (2 \times 167)$ lb. considering prolong duration of dead loads.
$\therefore W_3 = 334$ lb.

(4) $\therefore$ Total distributed dead loads on one roadbearer at point B (Fig. 22) is

$$W = W_1 + W_2 + W_3 = 3552 + 1576 + 334 = 5462 \text{ lb.}$$

(5) Max. B.M. due to (4) $= \dfrac{WL}{8} = 5462 \times \dfrac{(10 \times 12)}{8}$

$= 81930$ in lb.

(6) U.D.D.L. due to 6 tons knife-edge load per traffic lane and considering this on 3·5 ft. (Fig. 22) is

$$W = \frac{6 \times 2240}{10} \times \frac{3\cdot5}{1} = 4704 \text{ lb.}$$

This W travels as a point load from one end of roadbearer to another producing max. Bending when W is at midspan of roadbearer.

(7) $\therefore$ Max. B.M. due to (6) $= \dfrac{WL}{4}$ (concentrated load condition).

$$= \frac{4704 \times (10 \times 12)}{4}$$

$= 141120$ in lb.

(8) Total max. B.M. due to (5) and (7) is

$$B.M._{max} = 81930 + 141120 = 223050 \text{ in lb.}$$

(9) Assuming width of roadbearer to be 4″

$$\text{B.M.} = f\,z$$

$$\therefore\ 223050 = 2400 \times \frac{bd^2}{6}$$

$$\therefore\ d^2 = \frac{223050}{2400} \times \frac{6}{4} = 139 \text{ (approx.)}$$

$$\therefore\ d = 12 \text{ inches (approx.)}$$

Use sections of roadbearers each equal to 12″ × 4″.

Testing of Roadbearers against Shear :—

(1) Max. shear due to 0·453 ton per linear foot of each traffic lane is

$$S_{max} = \frac{3552}{2} = 1776 \text{ lb.}$$

(2) Shear due to 6 tons per traffic lane is

$$S_{max} = 4704$$

(*Note*.—Here the whole knife-edge load of 4704 acting at one end of roadbearer produces max. shear of the same value).

(3) Max. shear due to dead weight of decking of area (12″ × 4·5″) and one roadbearer of 10 feet span and 10″ × 4″ section is

$$S_{max} = \frac{788 + 200}{2} = 494 \text{ lb.}$$

(4) Total max. shear $= 1776 + 4704 + 494$

$$S_{max} = 6972 \text{ lb.}$$

(5) Now $\frac{S_{max}}{A} = s_a$ where S_{max} = Total shear

A = Area of cross section

s_a = Intensity of average shear

$$\therefore\ s_a = \frac{6972}{(12'' \times 4'')} = 145 \text{ lb. per sq. inch.}$$

(6) Now max. intensity of shear stress $s_m = \frac{3}{2} s_a$

$$\therefore\ s_m = \frac{3}{2} \times \frac{145}{1} = 217 \text{ lb. per sq. inch.}$$

(7) As actual s_m is greater than the permissible s_m for sal which is 180 lb. per sq. inch. ∴ section of roadbearer will fail against shear.

(8) Use a larger section say 12″ × 5″.

(9) $\therefore\ s_a = \frac{6972}{(12 \times 5)} = 116$ lb. per sq. inch.

$$\therefore\ s_m = \frac{3}{2} s_a = \frac{3}{2} \times \frac{116}{1} = 174 \text{ lb. per sq. inch.}$$

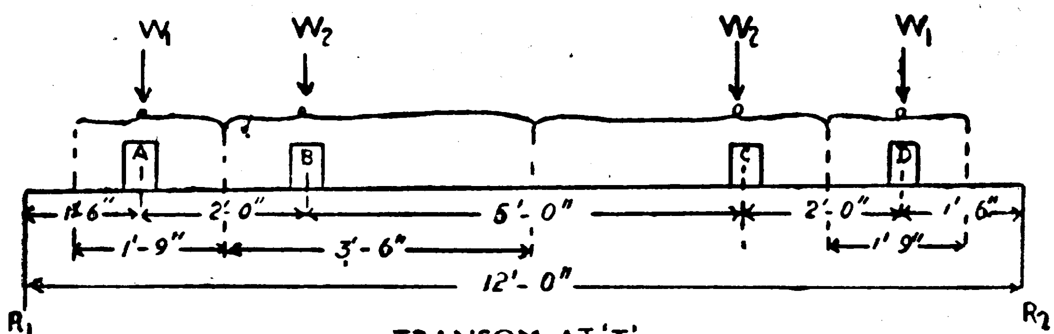
Now actual s_m is smaller than permissible s_m for sal which is 180 lb. per sq. inch.

Therefore use roadbearers each of 12″ × 5″ section which will be strong against bending as well as shear.

Testing of Roadbearers against Deflection :—As per method previously shown in Part I it will be found that section 12″ × 5″ is safe against deflection.

Design of Transom at T_2 :—See Fig. 23.

The position of transom 'T_2' and the nature of loads on it is as shown in (Figs. 23 and 24). The 6 Tons knife-edge load which is on 10 feet traffic width of the bridge comes on the transom T_2 of 12 feet span through four roadbearers A, B, C & D. First considering all loads except knife-edge load coming on transom T_2 we have (Fig. 24).



TRANSOM AT 'T'
TOTAL LOAD DISTRIBUTION
FIG 24

(*a*) Weight W_1 at Roadbearers A and D consisting of

(1) 100 lb. per sq. ft. of bridge surface on width 1′ 9″ and length 7′ 6″ (Figs. 24 and 23) is

$100 \times 1{\cdot}75 \times 7{\cdot}5 = 1312$ lb. .... a_1.

(2) Weight of portion of decking of area ($1{\cdot}75' \times 7{\cdot}5'$) and $4{\cdot}5$ inches thickness is

$$1{\cdot}75 \times 7{\cdot}5 \times \frac{4{\cdot}5}{12} \times \frac{60}{1} = 295 \text{ lb.}$$

Considering prolong duration of dead load we have twice 295 = 590 lb. .... a_2.

(3) Weight of roadbearer 'A' $7{\cdot}5$ feet long and of cross section $12'' \times 5''$ is

$$\frac{7{\cdot}5}{1} \times \frac{12}{12} \times \frac{5}{12} \times \frac{60}{1} = 188 \text{ lb.}$$

Considering prolong duration of dead weight of material we have twice 188 = 376 lb. .... a_3.

(4) ∴ Total weight W_1 excluding knife-edge $= a_1 + a_2 + a_3 = 984 + 590 + 376 = 1950$ lb.

(5) Considering 6 Tons knife-edge load over 1′ 9″ length of transom is

$$\frac{6 \times 2240}{10} \times \frac{1{\cdot}75}{1} = 2352 \text{ lb.} \quad \ldots\ldots a_4.$$

(6) Net weight W_1 including knife-edge load is $W_1 = 1950 + 2352 = 4302$ lb.

(*b*) Weight W_2 at roadbearers B and C consisting of

(1) 100 lb. per sq. ft. of bridge surface on width 3′ 6″ and length 7′ 6″ (Figs. 24 and 23) is

$100 \times 3{\cdot}5 \times 7{\cdot}5 = 2625$ lb. approx. .... b_1.

(2) Weight of portion of decking of area (3′ 6″ × 7′ 6″) and $4{\cdot}5$ inches thickness is

$$\frac{3{\cdot}5 \times 7{\cdot}5}{1} \times \frac{4{\cdot}5}{12} \times \frac{60}{1} = 590 \text{ lb.}$$

Considering prolong duration of dead load we have twice 590 = 1180 lb. ..... b_2.

(3) Weight of roadbearer 'B' 7·5 feet long and of cross section 12″ × 5″ is

$$\frac{7\cdot5}{1} \times \frac{12}{12} \times \frac{5}{12} \times \frac{60}{1} = 188 \text{ lb.}$$

Considering prolong duration of dead weight of material we have twice 188 lb. = 376 lb. .... b_3.

(4) ∴ Total weight W_2 excluding knife-edge load $= b_1 + b_2 + b_3$
$= 2625 + 1180 + 376$
$= 4181$ lb.

(5) Considering 6 Tons knife-edge load over 3′ 6″ length is

$$\frac{6 \times 2240}{10} \times \frac{3\cdot5}{1} = 4704 \text{ lb.} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots b_4.$$

(6) Net weight W_2 including knife-edge load is
$W_2 = 4181 + 4704 = 8885$ lb.

(7) Thus complete system of loading on transom 'T_2' is as shown in Fig. 25.

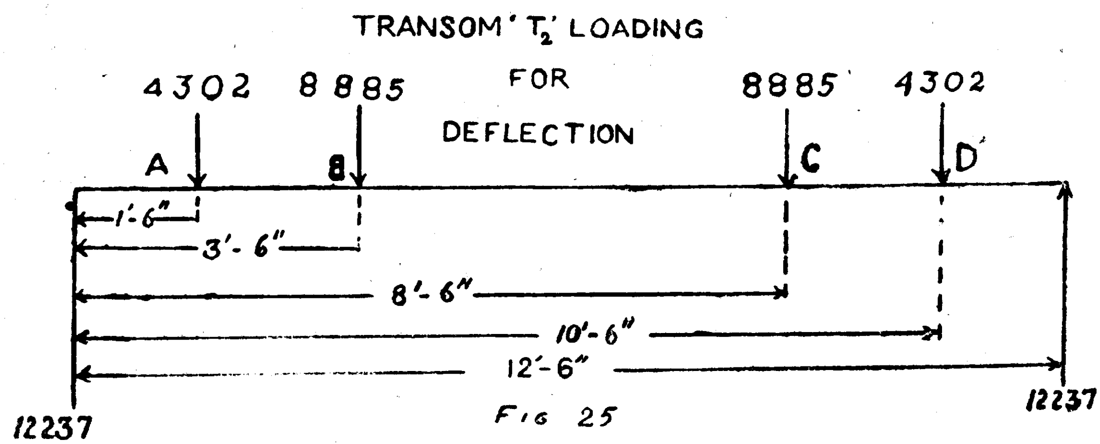


FIG 25

Again from Fig. 26, the load being symmetrical,

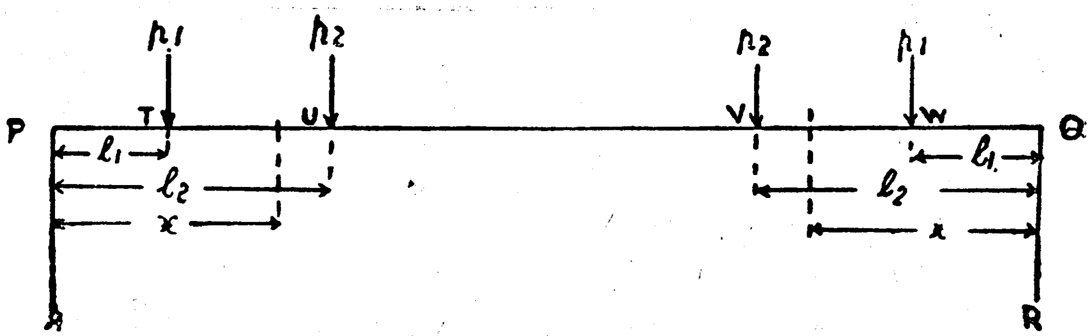


FIG. 26

(1) Reaction at P & Q will be equal & = R say and $2R = 2 (p_1 + p_2)$ or $R = p_1 + p_2$.

(2) B.M. at P & Q = O ;
It gradually increases to value $R \times l_1$, at points T & W.

(3) Considering a section at any point distance X from P or Q such that $l_2 > X > l_1$,
B.M. at this point is $R \times X - p_1 (X - l_1)$

$$= (p_1 + p_2) \times X - p_1 (X - l_1) \text{ because } R = p_1 + p_2.$$
$$= p_2 X + p_1 l_1 \qquad \ldots\ldots (1)$$

Hence from eqn. (1) we see that as X increases B.M. increases.
When $X = l_2$, B.M. $= p_2 l_2 + p_1 l_1$ at points U & V.

(4) Again from Fig. 27 and choosing a distance y from P or Q such that $y > l_2 > l_1$, i.e., the section lies between points U and V. We have

$$\text{B.M.} = R \times y - p_1 (y - l_1) - p_2 (y - l_2)$$
$$= (p_1 + p_2) y - y (p_1 + p_2) + p_2 l_2 + p_1 l_1$$
$= p_2 l_2 + p_1 l_1$, i.e., B.M. is same as at point U & V formerly found out.

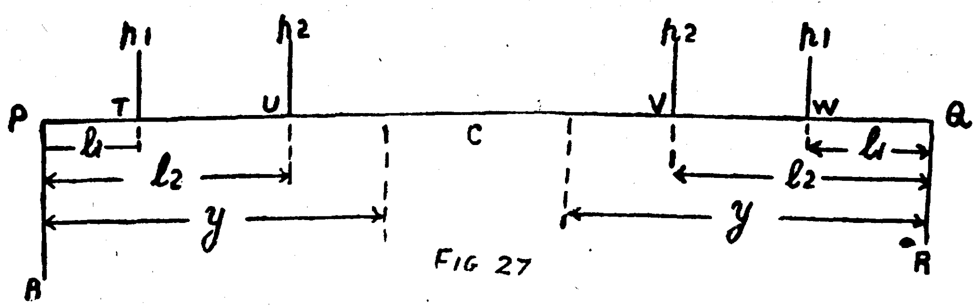


FIG 27

(5) Thus from Fig. 28 we see that B.M. has attained a max. value at points U & V and remains at that value in the region between U & V.
Now in our case $p_1 = W_1$ and $p_2 = W_2$
$l_2 = 3' \, 6''$ and $l_1 = 1' \, 6''$
We have

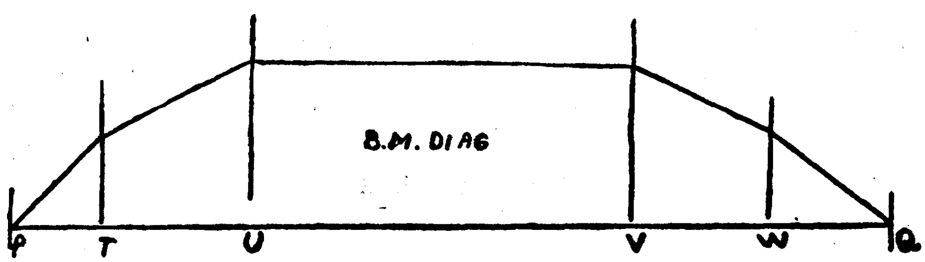


FIG 28

(6) B.M._{max}
$$= p_2 l_2 + p_1 l_1$$
$$= W_2 l_2 + W_1 l_1$$
$$= 8885 \times 3 \cdot 5 + 4302 \times 1 \cdot 5$$
$$= 31094 + 6453$$
$$= 37547 \text{ ft. lb.}$$
$$= 450564 \text{ in. lb.}$$

(7) Now $\text{B.M.}_{max} = f z$ and assuming width of transom to be 6 inches we have

$$450564 = 2400 \times \frac{bd^2}{6}$$
$$\therefore \; d^2 = \frac{450564}{2400} \times \frac{6}{6} = 187$$
$$\therefore \; d = 13 \cdot 6 \text{ inches (approx.).}$$

Use a transom of section $6'' \times 14''$

To test Transom 'T_2' against Shear :—

(1) Loadings on transom T_2 as per previous calculations are

Due to a_1	1312 lb.	not considering prolong duration.
,, a_2	295 ,,	
,, a_3	188 ,,	
,, a_4	2352 ,,	
,, b_1	2625 ,,	not considering prolong duration.
,, b_2	590 ,,	
,, b_3	188 ,,	
,, b_4	4704 ,,	

Total Wt. @ $W_1 + W_2 = 12054$ lb. Fig. 24.

(2) $\therefore$ Max. shear $= R_1 = R_2 = 12054$ lb.

(3) Now $\frac{S_{max}}{A} = s_a$

$\therefore s_a = \frac{12054}{14 \times 6} = 143$ lb. per sq. inch.

(4) $s_m = \frac{3}{2} \times \frac{143}{1} = 214$ lb. per sq. inch.

Now actual s_m is very much larger than the permissible s_m for sal which is 180 lb. per sq. inch.

Therefore section of transom 14″ × 6″ will fail against shear.

(5) Try section 16″ × 6″ for transom T_2.

(6) $s_a = \frac{S_{max}}{A} = \frac{12054}{16 \times 6} = 125$ lb. per sq. inch.

(7) $s_m = \frac{3}{2} s_a = \frac{3}{2} \times \frac{125}{1} = 186$ lb. per sq. inch.

Therefore section 16″ × 6″ is just safe against shear.

To test Transom T_2 against Deflection :—

(1) Deflection is max. where B.M. is max.

$\therefore$ Max. deflection will occur at the centre of transom.

(2) Total load coming on the transom through roadbearers is as shown in Fig. 25.

(3) To this loading in Fig. 25 is added deflection due to dead weight of transom acting as a concentrated load at centre 'C' Fig. 29.

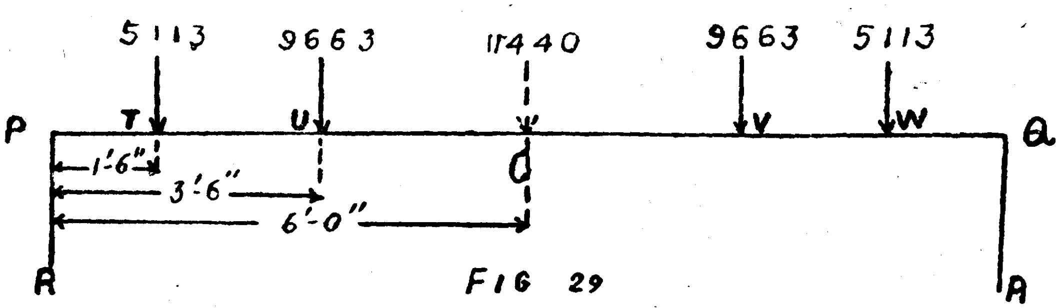


FIG 29

(4) Load at T and W is

a_1	= once × 984	= 1312 lb.
a_2	= 3 × 295	= 885 lb.
a_3	= 3 × 188	= 564 lb.
a_4	= once × 2352	= 2352 lb.
		5113 lb.

(5) Load at U and V is

$$\begin{aligned} b_1 &= \text{once} \times 2625 = 2625 \text{ lb.} \\ b_2 &= 3 \times 590 = 1770 \text{ lb.} \\ b_3 &= 3 \times 188 = 564 \text{ lb.} \\ b_4 &= 1 \times 4704 = 4704 \text{ lb.} \\ & \overline{9663 \text{ lb.}} \end{aligned}$$

(6) Load at C is

$$3\left(12 \times \frac{16}{12} \times \frac{6}{12} \times \frac{60}{1}\right) = 450 \times 3 = 1440 \text{ lb.}$$

(7) Now deflection at a point X due to a non-central load W (Fig. 30) is given by

$$\delta x = \frac{W \times a \times X}{EI\,(a+b)} \times \frac{b^2 + 2ab - X^2}{6}.$$

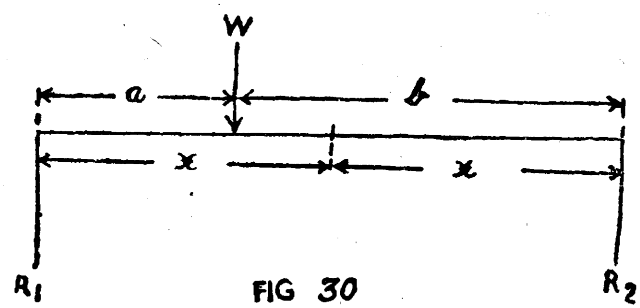


FIG 30

(8) ∴ δ at centre C of transom due to load 5113 lb. at T (Fig. 29) where a = 1·5 feet; b = 10·5 feet ; X = 6 feet is

$$\delta c = \frac{5113 \times 1{\cdot}5 \times 6}{E \times I\,(12)} \quad \frac{(10{\cdot}5)^2 + 2 \times 1{\cdot}5 \times 10{\cdot}5) - 6^2}{6}$$

$$= \frac{1}{EI} \times \frac{7668 \times 105{\cdot}75}{12}.$$

(9) Again δ at centre C of transom due to load 9663 at U (Fig. 29) where a = 3·5 feet; b = 8·5 feet ; x = 6 is

$$\delta c = \frac{9663 \times (3{\cdot}5 \times 6)}{EI\,(3{\cdot}5 + 8{\cdot}5)} \times \frac{(8{\cdot}5)^2 + (2 \times 3{\cdot}5 \times 8{\cdot}5) - 6^2}{6}$$

$$= \frac{1}{EI} \times \frac{9663 \times 670{\cdot}25}{24}.$$

(10) Again δ at centre 'C' of transom due to concentrated central load of 1350 lb. is

$$\delta c = \frac{1}{48}\,\frac{WL^3}{EI} = \frac{1}{48\,EI} \times \frac{1350 \times (12)^3}{I}$$

$$= \frac{1}{EI} \times \frac{1350 \times 36}{1}.$$

(11) ∴ Total deflection is that due to twice [(8) + (9)] + (10) as loads are symmetrical

$$\therefore \text{ Total } \delta c = 2\left[\frac{1}{2 \times EI}\left(\frac{7668 \times 105{\cdot}75}{6} + \frac{9663 \times 670{\cdot}25}{12}\right)\right] + \frac{1}{EI} \times \frac{1440 \times 36}{1}$$

$$= \frac{1}{EI}\,(135140 + 539640 + 51840)$$

Now 'E' for sal $= 2 \times 10^6$ lb. per sq. inch
$= 2 \times 10^6 \times 144$ lb. per sq. ft.

And I for the section of transom 15″ × 6″ is

$$\frac{b \times d^3}{12} = \frac{6 \times (16)^3}{12} \text{ in.}^4$$

$$= \frac{6}{12}\ \frac{6 \times (16)^3}{12 \times (12)^3} \text{ ft.}^4$$

$$\therefore \text{ Total } \delta c = \frac{1}{2 \times 10^6 \times 144} \times \frac{12 \times 12 \times (12)^3}{6 \times (16)^3} (726620)$$

$$= 0{\cdot}026 \text{ ft.}$$

Now max. allowable deflection $= \frac{1}{240}$ th of the span

$$= \frac{1}{240} \times \frac{12}{1} = 0{\cdot}05 \text{ feet.}$$

∴ Actual total δ is less than max. allowable deflection.
Hence design of transom is safe against deflection.

Design of Truss to span 20 feet bridge :—

The type of truss used is as shown in Fig. 31. Two trusses are used one at each end of the width of bridge.

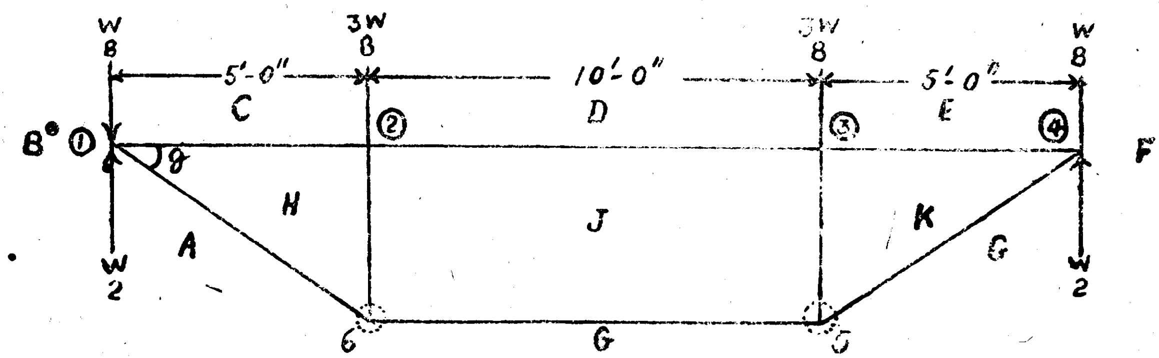


FIG 31

Let the total load coming on one truss be W. This load W is distributed over four node points (1), (2), (3) and (4) in the following ratios. Fig. 31.

At joints (1) & (4) $\frac{2{\cdot}5 \text{ W}}{20} = \frac{1}{8}$ W.

At joints (2) & (3) $\frac{(2{\cdot}5+5) \text{ W}}{20} = \frac{3}{8}$ W.

The resulting forces in the various members of the truss can be found by resolution of forces. At each joint (node point) resolving horizontal and vertical forces in equilibrium we get

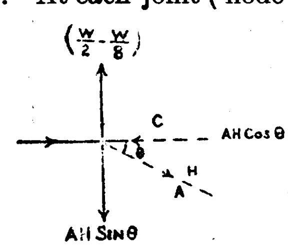


FIG 32

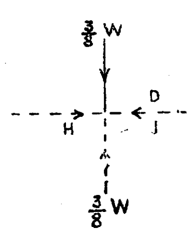


FIG 33

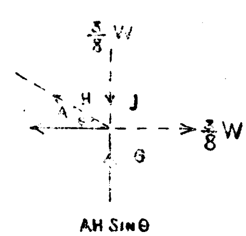


FIG 34

At joint (1) (Figs. 31 & 32) and joint (4)

$\left(\frac{W}{2}-\frac{W}{8}\right) - AH \sin\theta = 0$ 1a

and $AH \cos\theta = CH$ 1b

From 1a we get force in $AH = \frac{3}{8} W \operatorname{cosec}\theta$ (tensile)

From 1b we get force in $CH = \frac{3}{8} W \operatorname{cosec}\theta \times \cos\theta$

$$= \frac{3}{8} W \frac{1}{\sin\theta} \times \frac{\cos\theta}{1}$$

$$= \frac{3}{8} W \cot\theta \text{ (compressive).}$$

At joints (2) and (3) Figs. 31 & 33.

$\frac{3}{8} W = JH$ 2a

and $HC = DJ$ 2b

From 2a we get force in $JH = \frac{3}{8} W$ (compressive)

From 2b we get force in $DJ = \frac{3}{8} W \cot\theta$ (compressive).

At joints (6) and (5) Figs. 30 & 34.

$AH \sin\theta = HJ$ 6a

$AH \cos\theta = JG$ 6b

From 6a we get force in $HJ = \frac{3}{8} W$ (compressive)

and From 6b we get force in $JG = \frac{3}{8} W \cot\theta$ (tensile).

If $\theta = 45°$ then $\cot 45° = 1$

$\operatorname{cosec} 45° = 1{\cdot}414$

$\therefore$ Force in $AH = \frac{3}{8} \times \frac{1{\cdot}414}{1} W = \frac{3}{8} W = KG$

and Force in $CH = EK = JG = DJ = \frac{3}{8} W$

and Force in $HJ = JK = \frac{3}{8} W$.

Now load transmitted by Transom 'T_2' on one

truss at joint (2) $= \frac{1}{2}$ (wt. on transom + wt. of transom)

$= \frac{1}{2}$ (4302+8885+8885+4302+1440)

$= 13187+720 = 13907$ lb.

$\therefore$ Total load $\frac{3}{8} W$ at joint (2) $= 13907$ lb.

$\therefore$ Force in $AH = KG = \frac{3}{8} \times \frac{1{\cdot}1414}{1} W = 13907 \times 1{\cdot}1414$

$= 15873$ lb. (tensile)

and Force in $CH = EK = JG = DJ = HJ = JK = \frac{3}{8} W$

$\therefore$ Force in CH = 13907 lb. compressive.

DJ = 13907 lb. compressive.

EK = 13907 lb. compressive.

HJ = 13907 lb. compressive.

JK = 13907 lb. compressive.

JG = 13907 lb. tensile.

Design of truss members :—

(*a*) Member DJ ; length 10 ft. force compressive

(1) Try a section 5″ × 5″

(2) slenderness ratio $\frac{l}{d} = \frac{10 \times 12}{5} = 24$

$\therefore$ Design DJ as long column since $\frac{l}{d} > 15$

(3) Permissible stress for long column is

$$P_c = f_c\left(1 - \frac{l}{60d}\right)$$

$$\therefore P_c = 1700\left(1 - \frac{10 \times 12}{60 \times 5}\right)$$

$$= 1700\left(1 - \frac{2}{5}\right) = 1020 \text{ lb. per sq. in.}$$

(4) Actual stress on members $= \frac{W}{A}$

where W = 13907 lb.

A = Net area after deducting for joints, etc.

$= 25 - \frac{1}{3} \times 25 = 17$

$\therefore$ Actual stress $= \frac{13907}{17} = 818$ lb./sq. in.

• Permissible stress = 1020 lb./sq. in.

$\therefore$ Member DJ of 5″ × 5″ is quite safe.

(*b*) Member AH : Force tensile = 15873 lb.

As the force is tensile it will be practical to use a steel member

sectional area $= \frac{\text{load}}{f_t \text{ of steel}} = \frac{15873}{20000}$ where $f_t = 20000$ lb./sq. in.

$= 0 \cdot 7936$ sq. inches.

Use 1″ diameter rod of sectional area $0 \cdot 785$ sq. inches so as to allow for reduction of steel area at threaded ends and also reduction in strength of steel bar due to kinks at joints 5 and 6 Fig. 31.

(*c*) Member HJ : length 5 feet ; force compressive

(1) Try a section 3″ × 3″

(2) slenderness ratio $\frac{l}{d} = \frac{5 \times 12}{3} = 20$

$\therefore$ Design the member as a long column

Since $\frac{l}{d} > 15$.

(3) $P_c = f_c\left(1 - \frac{l}{60d}\right)$

$$= 1700\left(1 - \frac{5 \times 12}{60 \times 3}\right) = 1133 \text{ lb.}$$

(4) Net sectional area $= \frac{W}{P_c} = \frac{13907}{1133} = 12 \cdot 3$ sq. in.

(5) Actual area = net area + $\frac{1}{3}$ net area

$= 12 \cdot 3 + 4 \cdot 1$

$= 16 \cdot 4$ sq. inches

$\therefore$ Section 3″ × 3″ will fail.

(6) ∴ Use a section 4″ × 4″ which will just suffice
∴ Size of members of the truss is as shown in Fig. 35.

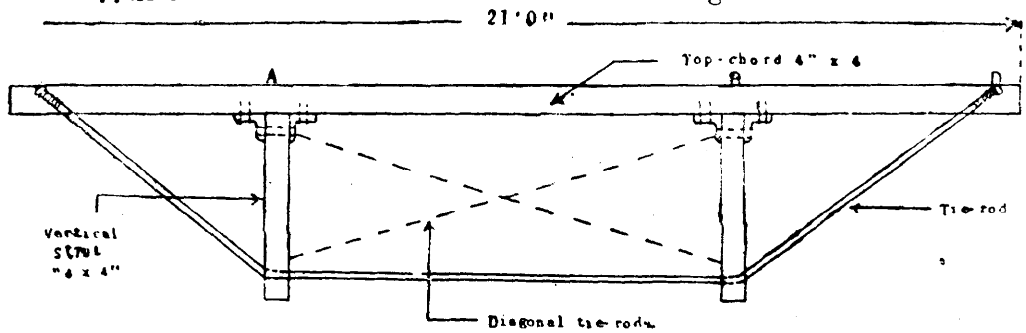


Fig. 35.

TABLE I

Sal timber required

A complete statement in tabular form of a Bridge (alternate design) 20 feet span, 10 feet traffic width, made of sal *timber of standard structural grade No. 2*

Serial No.	Name of Items	Section b × d	Sectional area per piece	Length per piece	Cu. ft. per piece	Number of pieces required	Total Cu. ft.	Constructional remarks	Serial No.
		in. × in.	sq. in.	ft. in.	Cu. ft.	Nos.	Cu. ft.		
1	Decking of sal sleepers								
	Main deck ..	12×3	36	12 0	3·00	20	60·00	1*a*, 1*b*, Fig. 36	1
	Wearing deck ..	12×1¼	18	10 0	1·25	20	25·00	Figs. 6 and 7, Part I	
2	Roadbearers or stringers ..	12×5	60	21 0	8·75	4	35·00	2*a*	2
3	Transoms ..	16×6	96	20 0	12·50	4	50·00	3*a*	3
4	Bridge seat ..	6×3	18	13 0	1·60	2	3·20	4*a*	4
5	Solid strutting or spacers	6×4	24	4 7 1 7	0·76 0·26	4 8	3·04 2·08	5*a*	5
6	Two Nos. Trussed Beams comprising of								
	Top chord ..	4×4	16	21 0	2·33	2	4·66	6*a*, Figs. 37*a*, 35	6
	Vertical struts ..	4×4	16	5 6	0·61	4	2·44	6*b*, Figs. 37*a*, 35	
	Steel rod ties ..	1″ dia.	0·785	25 0	0·14	2	..	6*c*, 6*d*, Figs. 37*a*, 35	
	Diagonal counter-bracing of 1″ dia. steel rod ..	1″ dia.	0·785	12 0	0·07	2	..		
7	Guard blocks ..	5×3	15	0 6	0·05	12	0·60	7*a*	7
8	Wheel guards ..	5×4	20	20 0	2·80	2	5·60	8*a*	8
9	Rail posts ..	5×4	20	4 0	0·55	10	5·50	9*a*	9
10	Hand rails ..	3×4	12	20 0	1·66	4	6·64	10*a*	10
11	Inclined struts for bracing rail posts ..	3×3	9	5 0	0·31	6	1·86	11*a*	11
	Inclined struts for bracing truss against wind ..	4×4	16	5 6	0·61	8	4·88	11*b*, Fig. 38	

Total timber required 210·10 u. ft.

NOTE ON CONSTRUCTIONAL REMARKS FOR

(1*a*) Same as that for 15 feet span bridge Table I, remarks 1*a*, Figs. 6 & 7, Pt. I.

(1*b*) Over the main decking sleepers nail $1\frac{1}{2}''$ thick sal planks (wearing deck) at right angles to main decking and in six feet lengths. Between ends of every six feet length nail down one 10″ wide and $1\frac{1}{2}''$ thick plank transversally to wearing deck see Fig. 36.

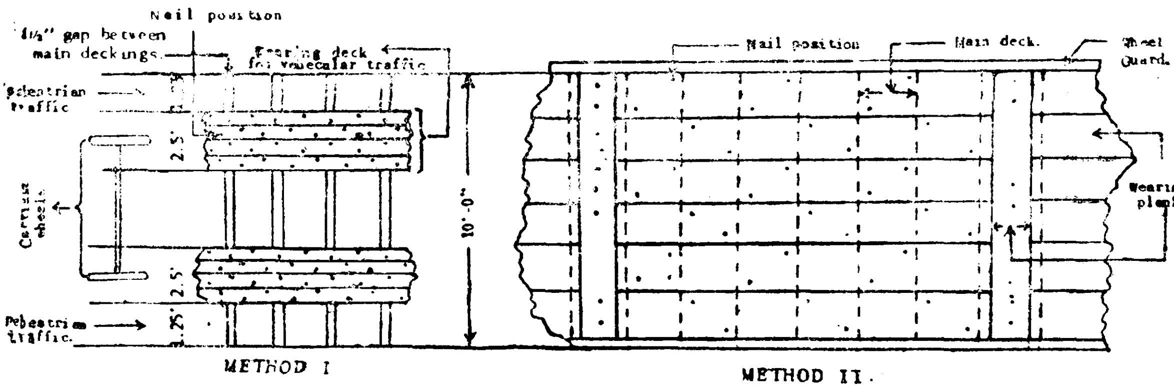


Fig. 36.

(2*a*) Same as that for 20 feet span bridge, Table I, Pt. II, remarks 2*a*, and Figs. 6 and 7, Pt. II.

(3*a*) Same as that for 20 feet span bridge Table I, Pt. II, remarks 5*a*.

(4*a*) Same as that for 15 feet span bridge Table I, Pt. I, remarks 2*a*.

(5*a*) Same as that for 15 feet span bridge Table I, Pt. I, remarks 2*b*. Chase mortise joint in addition.

(6*a*) (1) Top chord 'AD' Fig. 37 (see page 444) may be composed of three length 6′, 10′ and 6′ (i.e., AB, BC and CD in Fig. 37) butting over the heads of struts and fished together by strap and bolts.

(2) If one piece length of 22 feet is available, top chord then may be in one piece, stiffened at strut positions 'A' and 'B' by angle iron cleats. Fig. 35.

(3) It possible the length of individual pieces of timber should be kept below 20 feet due to non-availability of long length timbers. It is usually cheaper to use a long length whenever available rather than to splice two shorter pieces as timber joints are weak.

(6*b*) The two struts should always be counter-braced in the middle for use in a bridge as they are subject to moving loads. Counter-bracing to consist of 1 inch diameter steel rods diagonally braced Figs. 35 and 37.

(6*c*) } (6*d*) } Joints as shown in Fig. 37.

(7*a*) See Fig. 10 of Pt. II and remarks 5*a* of Pt. I, Table I.

(8*a*) See Fig. 1 of Pt. II.

(9*a*) See Fig. 10 of Pt. I. } Remarks same as that in Pt. I, Table I, remarks 5*a*.
(10*a*) See Fig. 10 of Pt. I. }

(11*a*) Same as that for 15 ft. span bridge Table I remarks 7*a* and Fig. 7.

(11*b*) (1) Wind bracing to large timber structure is essential.

(2) In the case of our bridge under construction, it could be efficiently met with by joining vertical struts of two trussed beams at their feet with a piece of timber 4″ × 4″ section as shown in Fig. 38 and the heads of wind bracing struts joined to bottom of transoms by bent straps as in Figs. 38 and 39.

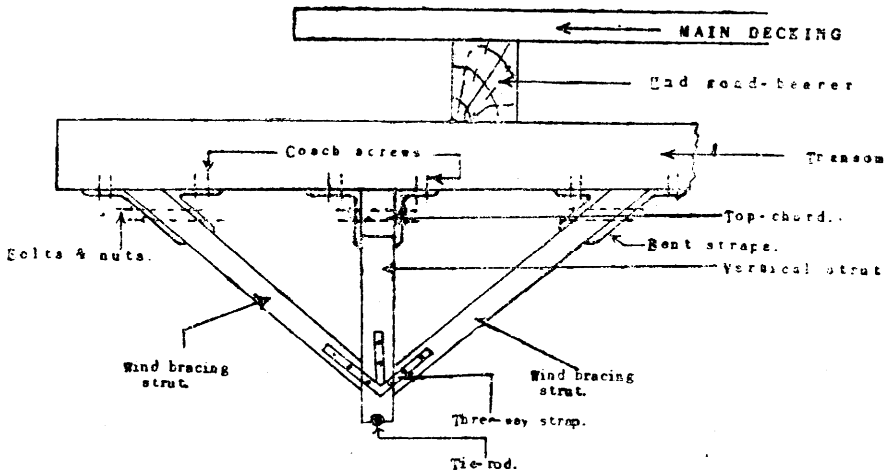


Fig. 38.

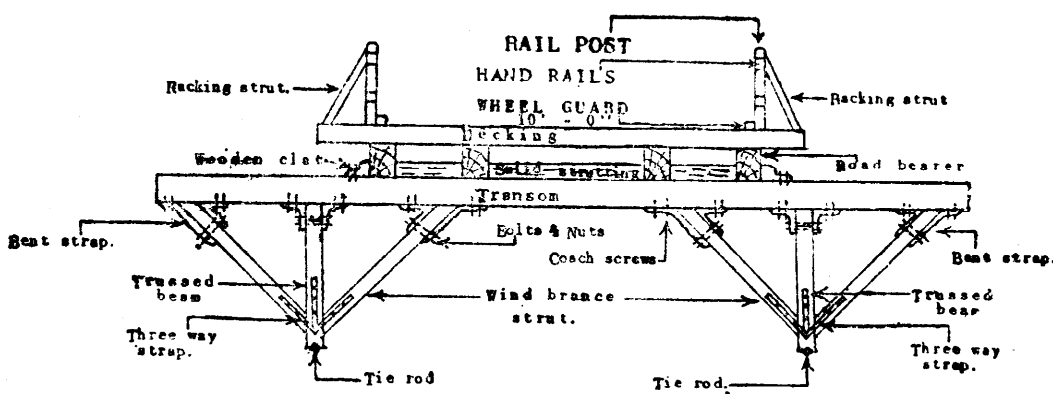


Fig. 39

TABLE II

Hardware required for 20 feet span bridge (alternate design)

Serial No.	To connect	Bolts and Nuts Dia. (inch)	Bolts and Nuts Length (inch)	Bolts and Nuts No. required (Nos.)	Iron washers Thickness (inch)	Iron washers Dia. (inch)	Iron washers No. required (Nos.)	Nails 3" long and $\frac{3}{8}$" dia.	Spikes 6" long and $\frac{1}{4}$" dia.	Constructional remarks	General remarks
1	$1\frac{1}{2}$-inch planking with main decking.	..	..	..	..	..	..	200	..	1a, Fig. 36	..
2	Main decking to road-bearers.	..	..	..	..	..	..	..	160	2a	..
3	Roadbearers to transoms with the help solid strutting and timber cleats.	$\frac{3}{4}$ Drift bolt	10	8	..	..	..	..	..	3a, Fig. 39	Use $\frac{3}{4}$" drift bolts instead of bolts and nuts.
4	Transoms to trussed beams.	$\frac{3}{4}$	$7\frac{1}{2}$	8	..	..	..	..	..	4a, Fig. 39	Drift bolts used. Use mild steel bent strap with bolts and nuts.
		$\frac{3}{4}$ coach screw	5	16	..	..	..	..	..	..	..
		$\frac{1}{2}$ strap	10	8	..	..	..	..	..	..	..
5	Trussed beams erection: Top chord to struts.	$\frac{1}{2}$ strap	18	8	..	..	..	..	..	5a, Fig. 37a	Use 'T' type strap.
	Steel rod tie to top chord and vertical struts.	1" M.S. bar	25 ft.	2	$\frac{1}{4}$	$2\frac{1}{2}$	4	..	..	5b, Figs. 37a and 37b	Use steel rod with ends threaded and bolted.
	Diagonal counter-bracing of 1" dia. steel rod.	1" M.S. bar	12	4	$\frac{1}{4}$	$2\frac{1}{2}$	8	..	..	5c, Figs. 37a and 37b	
6	Trussed beams to bridge seat.	$\frac{3}{4}$ Drift bolt	6	16	..	..	..	..	..	6a, Fig. 40a	In addition solid strutting may be resorted to.
		$\frac{3}{4}$ Lewis bolt	..	6	$\frac{1}{4}$	$2\frac{1}{2}$	6	..	..	6b, Fig. 40b	..
7	Guard block and wheel guard to main decking.	$\frac{3}{4}$	12	12	$\frac{1}{4}$	2	24	..	..	7a	Same as that in Figs. 9 and 10, Pt. I.
8	Rail posts to main decking.	..	..	..	..	..	..	..	..	8a	
9	Hand rail to rail post.	$\frac{1}{2}$	9	20	$\frac{1}{4}$	2	40	..	..	9a	
10	Inclined struts to rail post and decking.	..	..	..	..	..	..	..	20	10a	See Fig. 7 of 15 ft. span bridge, Pt. I.
11	Inclined struts to wind-brace trussed beams.	$\frac{1}{2}$	$5\frac{1}{2}$	32	..	..	..	..	..	11a	Use three way bent strap, Fig. 39.
		$\frac{1}{2}$	$5\frac{1}{2}$	16							
		$\frac{1}{2}$ coach screw	4	32	..	..	..	..	..	11b	Use mild steel three way strap, Fig. 39.

NOTE OF CONSTRUCTIONAL REMARKS HARDWARE TABLE II

(1*a*) Same as that for 1*a* in Table II Hardware required for 15 feet span of bridge. See Fig. 36.

(2*a*) Same as that for 2*a* in Table II Hardware required for 15 feet span of bridge.

(3*a*) See Fig. 39. End roadbearers secured to transoms through timber side cleats and drift bolts. Intermediate roadbearers are kept in position by spacers as in Figs. 6 and 8, Pt. I.

(4*a*) See Fig. 39.

(5*a*) Use a tee junction strap on both sides of top chord and strut in case of three separate lengths making one top chord Fig. 37.

In case of single available length of top chord, use angle straps underneath top chord at junctions of struts as in Fig. 35. This strengthens the junction at A and B and also makes the top chord to act as 'long columns' for purposes of calculations.

(5*b*) See enlarged joint at E & F and A & D. Figs. 37*a* and 37*b*.

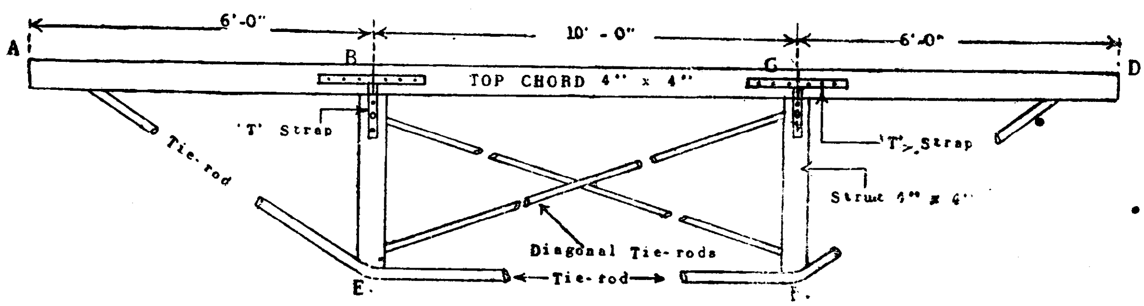


Fig. 37a.

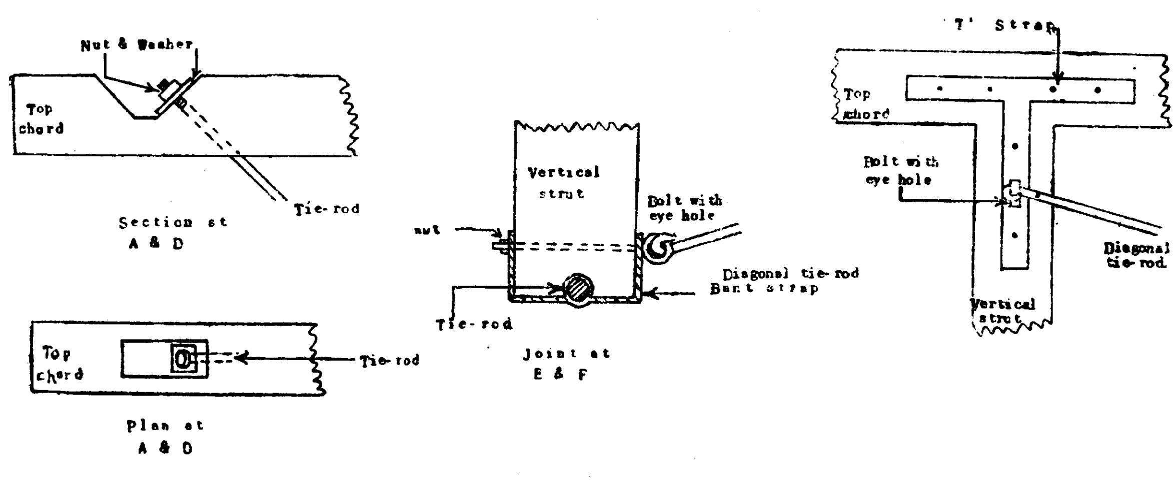


Fig. 37b.

(5*c*) See enlarged joint at F and B. Fig. 37.

(6*a*) Top chord of trussed beams are drift-bolted to bridge seats through timber side cleats. Fig. 40.

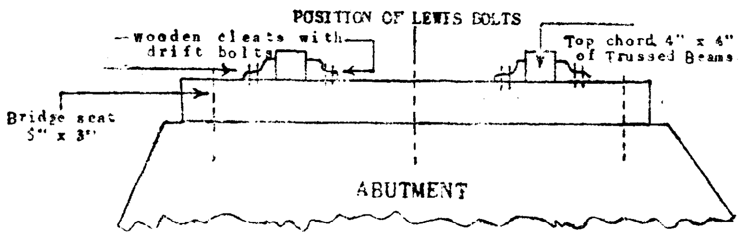


Fig. 40a

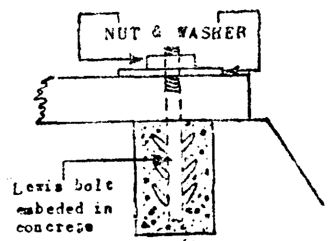


Fig 40b

(7*a*), (8*a*), (9*a*) Same as that in 5*a*, 6*a*, 7*a* in Table II, Pt. I and Figs. 9 and 10, Pt. I.

(10*a*) Same as that in 7*a* Table II, Pt. I and Fig. 7, Pt. I.

(11*a*) Use three way bent strap with bolts and nuts at feet of struts and bent straps with bolts, nuts and coach screw at head of wind-brace struts with the bottom of transom as in Fig. 39.

Note :—From the designs of 20 feet span bridge in Pt. II and Pt. III it bears out that design in Pt. II is more economical in timber and hardware and much simpler to construct than that in Pt. III.

It would be noted that in Pt. II there is a horizontal thrust on the abutments which should be provided for against shear in abutment at that point. In case of Pt. III there is no such horizontal thrust on the abutments.

NOTE :—Separate copies of this article can be obtained from the P.L.O., F.R.I. and Colleges, Dehra Dun on payment.

SIMLA-KULU-MANALI-ROHTANG

BY A SWISS TOURIST

Foreword.—Madam Haifliger has recently toured in the interior mountains of Seraj and Kulu Divisions and at my request has written this article in the form of a letter to me. I have her permission for publishing it.

I have not made any alterations in her language as the continental English has its own fascination.

(Sd.). Sunder Singh,
Conservator of Forests,
North Circle, Punjab, Simla.

Simla 5th July 1950

Dear Mr. Sunder Singh,

End of last week I returned to Simla and would have called on you but for my sore Lip which I have since Manali and which takes much longer to heal than I thought. So I am writing now to you, to thank you, again for all your kindness and help to smooth out the difficulties of my trip to the Rohtang Pass and to have informed all the Rest-houses of my coming. My mentioning of your name seemed like the golden key to open every door for me, and every where I found kind and helpful reception by your officers and always was made comfortable.

These Civil Forest Rest-houses are charming and beautifully situated, with a lovely view in front and a restfullness about them which does honour to their names. I enjoyed every stage of the trip from Simla, when I saw you last at the Bus Station, to the Rohtang Pass and back over Amritsar, which return trip I did by Bus from Manali to Pathankote.

The snow mountains on my arrival in Narkanda showed themselves in their full glory ; so did they again, much nearer, on the Jalory Pass ; and last and almost within reach, on the Rohtang Pass, as if to salute the one, who came to admire them ; because often, after and before my arrival I struck fog and rain and even storm and could easily have found them vailed by clouds, so I was doubly grateful always to get a wonderful view at the most important moment.

My great admiration also have the beautiful forests. The Deodar trees round Manali will always be in my memory as specially grand and old specimens, many hundred years old, I was told. And the charming little Temple near Manali, dedicated to the Goddess Hirma Devi, the patron of the Kulu Valley, to whom in former times human sacrifices have been made, was surrounded by 800 years old trees, as Major Banon told me. I went to visit it nearly daily during my 3 weeks stay in Manali and never the spell wore off. How grateful one must be to the Forest Department that they take these Forests under their special care and dont allow any vandalism, which has destroyed so many beautiful forests in other countries ; damage which cannot be repaired in Generations, has robbed the countries of their beauty and changed the climate for the worse.

I am a great lover of trees and so enjoyed always most the marches which led through forests, as did the first part from Narkanda to Luri with its various kinds of old big trees. The second part along the steep and bare mountain side in the burning sun, reminded me much of Northern China, and I was glad when the 13 miles came to an end and I reached Luri with its bright clean Rest-house. I made the 7,000 feet descent by foot as no ponies or mules were available at Narkanda.

From Luri to Ani I got mules but did most as everywhere, on foot. The mules have the most unpleasant habit of walking stubbornly on the outmost ridge over a steep abyss, so that one is afraid to loose ones balance and go down headlong hundreds of feet, though the cool looking Sutlej for instance would have made a welcome change to the hot walls of the rocky mountain side. Trying to keep ones equilibrium on a mule without a saddle stirrups or reins with half the tummy of the mule, and with it ones own leg always in the void, calls for so much keen attention, that there is no hope of enjoying the vistas and so I walked, feeling safe and happy.

In Ani I was invited very kindly by your friend Raja Raghvir Singh and spent a very nice and entertaining day with him, and partly also with his wife and sister-in-law on his picturesque Estate overlooking the Ani Valley. He also procured me mules the next day, which I had not been able to do myself the previous day.

The march to Kanag along the river Ani became more and more beautiful as more as we advanced and left the Ani below. The forest and the green meadows in between, and not least the alpine character of the top of the mountain, the Rest-house overlooking the mountain ranges and valley we had come through made me almost feel I was at home in Switzerland, which I felt more or less along the whole, route with very small variations. Of course, the proud Deodar is replaced in my country by Pines and other kinds ; still, I felt at home and did also with the people I met, kind and lovable as they were.

That day in Kanag I had the Rest-house all to myself and a terrible storm broke loose and threw my doors open in the middle of the night ; but I thought it grand, I always admire the forceful outbreak of nature.

Next day we had to make a small detour as the storm had felled a tree across our path. It was a lovely march that led us through Forests, along mountain sides to Soja, reaching its comble at the Jalori Pass with as an unexpected surprise, a full clear view of the Snowpeaks of the Western Himalayas the sight I so much waited for.

On the ridge was still some snow and there I met one of your officers, a very nice young Sikh. We walked together to the Soja Rest-house, the loveliest of all, I think with a big lawn in front of it, on which again to remind me of my country, I found to my surprise "Edelweiss". Naturally I took some as a Souvenir of Soja.

That evening I was treated by your young officer to an excellent trout dinner and lots of other good things, which I enjoyed all the more as for the last 2 days I had nothing to eat but two Eggs. This of course was my own fault, as I did not bring any foodstuff with me except Coffee, Tea, Sugar and Milk, just the things I got everywhere. I was sorry to leave this place, the forest full of flowering lilac Iris. But the big Deodar trees on which I had looked down from Soja swallowed me up next morning in walking down to Banjar and I felt in my element. If I had a nice voice I am sure I would have been singing all the way.

It was, though at first rather steep, easy going all along and a long way through forest, till the green valley opened up with its picturesque looking little villages and its freshly cultivated paddy-fields. There wont be a famine, I am sure, this year as a lot of field-work had been done and the people looked content. In Banjar it became hot again and it was the last of the nice Civil Rest-houses stayed in. There were again difficulties about the mules but it ended well and next morning I left, as usual early along the hot valley, passed Larji and went straight on to Out. There I read on a board on the road "Bridlepath to Simla 104 miles", so that was what I had done, and I am glad I did it from Narkanda on foot and mule, before the road was finished and open to the Motor traffic.

From Out I left by lorry to Kulu. The road was full of festivly dressed people who must have gone to a Fair. I admired the colourful saris and the bright jewellery of the women. But also the men seem to have donned their best, and many of them were adorned with flowers. They all looked very happy.

Kulu was the last stage, where I stayed in a Dak-bungalow, before I came to Manali. Now from Kulu I have to tell you of a small incident which greatly touched me. I was sitting in the evening on the verandah of the Bungalow, overlooking the very big lawn with all its beautiful trees, when an Indian Gentleman came out of his room and we exchanged a few words, whereby he learnt that I was Swiss. On this he invited me to a trout dinner, saying that he had heard from several Indian travellers to Switzerland that the Swiss people were very hospitable and that, though he himself had never been to Switzerland, wanted to do something in gratitude. When he heard I had already ordered my dinner he still sent me some Trout and Mangoes to my room, as a supplement to my meal. I was impressed by that nice gesture and hope my people deserve this homage paid to them.

The road to Manali along the Beas river was again full of colour. I, always and in every country, noticed, that mountain people are

happy people. Living so near to Nature must make them more content with life.

Manali as I said before, was surrounded by lovely Deodar forests and I was not sorry that when crossing the stony Beas river I fell over a rock and sprayed my right arm which put it out of use for a week I was forced to interrupt my march to the Rohtang Pass. I spent 3 weeks in Manali, up on the mountainside in a romantic little Bungalow, overgrown with Roses and surrounded by forest, which I had all to myself.

The tour to the Rohtang Pass was then the last onward stage of my journey. Through the wild and beautiful valley of the upper Beas river where in lovely wooded surroundings, I stayed for the night in the Rest-house. Next day was a dense fog, so I had to stay another day but fortunately the second morning it cleared up and with the Pony and the carrier I left at 7 a.m. As we walked on, the track became more wild and more beautiful, with big waterfalls on the right and big trees on both sides which however we left soon below ; and two very steep and stony long ascents led up through snow fields to the top of the Pass. There I had a little disappointment. I had imagined that as soon as the Pass was reached one would have, as in Narkanda and Jalori Pass the full view of the snow mountain range. But we had to follow the Pass to the end for a half an hour through snow, and climb the ridge to face the peaks and look on to the huge Glacier frozen waterfalls across the narrow valley. Though we had started in clouds, the sight was free now, and I saw all the peaks that could be seen towards Kyelong and towards Sipiside, and the one pointed Pyramid which was the highest of all, 19,000 feet above sea. I stayed for one hour till the icy wind drove us back through the snow, down the tedious rocky descent, into the lovely valley below and back to Koti.

We met on our way, many and endless herds, snow-white longhaired mountain goats and sheep accompanied by their picturesque shepherds in white woolen short skirts like Ballerina frocks, and wrapped round their white coats many yards of brown thick cord. A clever Regisseur might find here the idea for an effective stage setting. Many tents were pitched along the roads by Caravans coming or going to Lahaul. And so the whole trip had been full of interest, a worthy finale to my expedition.

Content with my experiences I went back to Manali stayed a few more days in my Rese cottage, and packed with nice and good memories, I took the bus to Mandi where I arrived after 8 hours drive through more lovely gullies gorges and mountain passes, and next day to Pathankote and on to Amritsar. There, after all this God made beauty, I paid homage to a man made piece of Art—The Golden Temple of the Sikhs the Drwarsaheb—which also will stay in my memory of beautiful things.

And now back in Ticino—like Simla I thank you again and am with kindest regards also to your charming wife.

Yours sincerely,
(SD.). A. HAIFLIGER.

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CHO RECLAMATION AND ANTI EROSION WORKS IN HOSHIARPUR SHIWALIKS

BY THAKUR JHUNNA SINGH, I.F.S.
(*Chief Conservator of Forests, Punjab*)

The Cho menace in the Hoshiarpur has assumed alarming proportions. Out of a total area of 1,428,480 acres of this District as much as 250,000 acres is under the Chos (hill torrents locally known as Chos). The origin of this menace can be traced as far back as 1852 when, the once enviably protected forest and vegetated hills were transferred to individual proprietorship and the subsequent uncontrolled fellings, firing, grazing and browsing that followed in its train to meet the ever increasing demand of the steadily developing towns and habitation near the hills. The problem attracted the attention of the Government as early as 1877 when Mr. Baden Powel the then Conservator of Forests, Punjab drew up the first report recommending ways and means of checking these hill torrents. In 1895–96 a special enquiry committee was appointed to go into the matter, whose deliberations were followed by the enactment of Land Preservation Act (Chos Act) in 1900, whereby the local Government was empowered to restrict or regulate the rights of grazing and wood cutting in the Shiwaliks.

2. The Chos Act was first applied to 142 villages in 1902, in Dasuya, Garahshankar and Hoshiarpur Tehsils, when the enforcement of the provisions of the Act was entrusted to the Civil Authorities. In 1934–35 the forest management was brought under the control of a senior Forest Officer who was attached to the Deputy Commissioner and later in 1939 the Forest Department assumed full responsibility for protection and afforestation of the denuded hills to arrest the erosion.

3. Since the transfer of control to the Forest Department 461,497 acres area has been closed to browsers and out of this 206,214 acres has been closed to grazing as well, mainly voluntarily by the villagers, through the persuasive efforts of the Forest and Co-operative Departments. Effective closure is the most essential requisite in afforestation of the denuded hills and restoration of vegetative cover of the waste land. This afforestation of the hills is the only possible way of stopping the rush of water and sand on to the plains and controlling the ravages of floods in the Chos. Vegetation in the catchment alone can ensure impeded rain-water run off, greater moisture absorption and storage of water in the subsoil and reduction in the intensity and duration of floods in the streams.

4. *Cho-Menace Committee.*—In 1932 a Punjab Erosion Committee was appointed which advised the Government to restore vegetation in the denuded catchment even if by restricting age-long rights and privileges of the people. The Committee recommended that 'Engineering works are not a practical proposition'. There is only one way of stopping the rush of water and sand on to the plains and that is by afforesting the hills.

5. In 1948 a Cho Menace Committee was appointed by the Government to study the extent of devastation caused by Chos in Hoshiarpur District and suggest remedial measures to overcome Cho menace. The recommendations made by the Committee are briefly :—

(i) Closure to grazing.

(ii) Afforestation in the hills and the belas.

(iii) Consolidation of Cho banks by vegetation with the object of training the Chos. Soil conservation works, viz., check-damming and gully plugging, contour trenching and sowings thereon bela planting and so on.

(iv) Prohibition of sloping cultivation unless such lands are properly terraced.

(v) Digging guide channels in Chos by bull dozers.

(vi) Eviction of browsers by legislation.

(vii) Expediting consolidation of holdings for successful execution of control measures.

6. Another Conference of the Forest, Agriculture and Co-operative Departments was held at Simla on 17th March 1950 to discuss the Cho menace and suggest remedial measures. The Committee recommended :—

(1) Sections 35 to 37 of I.F. Act be amended on the lines of the Punjab Conservation of Manure (Amendment) Bill, 1950 (Section 3) whereby the Deputy Commissioner be empowered to issue notice and settle the closure case within 30 days from the day notice is issued, then effect closure.

(2) The Committee adopted that the sloping and undulating land being more severely ravined on account of cultivation on steep lands, the run off from such areas contributes at least half of the flood water in Chos and as such levelling and terracing of cultivated lands along slopes mainly by bull dozers and reclothing of waste land is very essential.

(3) The Committee further adopted the recommendations of the Cho-Menace Committee with regard to eviction of browsers by legislation, speeding up of consolidation of holdings and and purchase of bull dozers for terracing.

7. *Practical work done by Forest Department.*—Since the control of the Forest Department in 1939, 10,629 acres area has been sown with *Khair*, *Kikar*, *Phulahi*, 4,712 acres planted mainly with *Shisham*, 7,885 acres planted with bhabar grass, 5,655 acres contour trenched and 13,182 acres check dammed up to 1948–49. During the year 1949–50 alone 743 acres were sown with *Khair*, *Phulahi* and *Kikar* and 400 acres planted with mainly *Shisham* and other species, 240 acres planted with Bhabhar, 955 acres contour trenched and 1,765 acres check-dammed. As a result of protection, afforestation and other soil conservation works in the catchment and Cho-training works in the plains, 13,500 acres has been reclaimed from the sandy Cho beds and rendered culturable. Trenching, sowing and planting work is being undertaken on a very elaborate scale as would be seen from the year's work.

8. *Effect of soil conservation measures in rise in water leved.*—Since the enforcement of closures and commencement of practical soil conservation means many wells and springs in Una and Hoshiarpur Tehsils which had once dried up, have revived again. The water in streams now flows over a longer period during the year than before. Similarly a very large number of wells in Hoshiarpur, Garahshankar, Dasuya and Una Tehsils have recorded a rise in water level varying from 1 to 20 feet. Considerable area has been brought under irrigation as a result of rise in water level.

9. *Future programme of the Forest Department.*—It is proposed to extend closures and tackle 44,812 acres of waste land in the District, in addition to other waste land that remains to be closed. Check-damming and gully plugging in the upper reaches of the catchment, contour trenching in the gently sloping waste land, sowing both in the hills and in the plains and planting in the plains are to continue on as large a scale as possible. Terracing and levelling of sloping fields which has hitherto been very slow for want of adequate machinery, is to be undertaken on a larger scale, when more bull dozers and terracers are made available. However, with gradual extension in closures the work may extend to a period of 15 years (subject of course to availability of funds) by which time all the sloping cultivations are expected to be terraced and culturable land reclaimed and Chos canalized and their banks consolidated.

THE ECOLOGY OF THE HUMUS LAYER IN SOME ENGLISH FORESTS*

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PART II

(*Continued from the* " Indian Forester ", *October 1950, page 418*)

RATE OF DECOMPOSITION OF ORGANIC MATTER IN SOILS OF THREE TYPES

A relative estimate of the rate of decomposition of organic matter in field in the three classes of soil was obtained by :—

(1) measuring the volume of CO_2 given off by the soil in a unit time, and

(2) by estimating the amounts of nitrates present in them.

CO_2 estimates were arrived at in the field by absorbing in a standard solution of Barium Hydroxide the gas produced by soil enclosed under a bell jar for one hour. The solution was then titrated against a standard acid and results calculated as milligrams CO_2 produced by one square meter area of soil in one hour. In these estimations it may be noted that some CO_2 of the air was also included. In soils of Class 3, on which plants of *Mercurialis* and *Urtica* were growing vigorously, it is likely that some of the CO_2 produced by these soils was used by these plants directly. In the estimates given in Table 15 no corrections were made for these factors.

Table 15.—Milligrams CO_2 evolved during one hour from soils of different classes from one square meter area during the week ending April 21–26, 1947.

No.	Soil Type	Mgs. CO_2 (average)	Average for soil	Organic matter (on % dry wt. of the soil)	Ratio of CO_2 and organic matter
1	Bare areas	397	397	14·3	27·7
2	Chamanerion	329	313	7·9	40
	Pteridium—Scilla	297			
3	*Brachypodium*	280			
	Mercurialis	176	208	5·3	40
	Mercurialis—Urtica	168			

It appears that soils of Class 1 were giving off higher volumes of CO_2 during the week ending April 21–26 than those of Class 3. This may be due to the fact, as already pointed out, that some of the carbon dioxide in soils of Class 3 is being used up by plants as soon as it is produced. In soils of Class 1, with no ground vegetation all CO_2 produced by soils is absorbed in Barium Hydroxide, thus registering higher volumes. It can also be possible that in soils of Class 3 in which activity starts earlier in the spring the CO_2 production may by the end of April have fallen off from an earlier maximum. It is generally considered that the activities of the soil bacteria reach their maximum from January to March. The observed decomposed state of freshly fallen litter in sites of Class 3 at the time of making CO_2 estimates seems to support this view. In soils of Class 1 the litter was just beginning to decompose by the end of April. Whatever may be the exact explanation for these figures it is almost certain that the CO_2 produced is proportional to the organic content of the soil in the soils of Class 3 and 2. In the soils of Class 1 the proportion is lower, which may mean that the production of carbon dioxide in these soils is slower. If this is the case the nitrate formation in soils of Class 1 would be very small as compared with soils of Class 2 and 3, because the nitrate formation becomes active in soils only when the C : N is

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considerably narrowed (Waksman, loc. cit.) by evolution of CO_2. It was actually observed that in soils of Class 1 the quantity of nitrates was small whereas it was abundant in soils of Class 2 and 3. Relation between the CO_2 and nitrates produced in soils is shown in Fig. 12.

The CO_2 of the soil is usually assumed to increase acidity of the surface layers of the soil. Some CO_2 data plotted against pH in *Fig.* 13 *shows that soils with low* CO_2 *were* usually less acid, while those giving off higher volumes of CO_2 registered low pH values during the month of April 1947.

The CO_2 in soils usually increases with an increase in temperature of the soil and as shown in Fig. 14 the relation is more or less direct during spring. The higher volumes of CO_2 produced in summer and lower in winter are reported by many workers, which though related to the effects of temperature must also be governed by factors such as soil organic matter, moisture, etc.

The evidence on CO_2 and nitrate production, on the whole seems to suggest that in soils of Class 1 decomposition was slower than in soils of Class 2 and 3. These results thus agree with the observations of Hesselman (loc. cit.), Ramann (loc. cit.), etc., that decomposition of plant material is slow in mor soils, which it will be shown correspond to the soils for Class 1 in these woods.

Tree Vegetation, Soil Types and Ground Flora Communities

A relation of chemical composition of litter with soil types and ground flora communities may be summed up as under :—

1. *Soils of Class 1.*—The litter in most cases is generally of a high C : N and high C : bases ratio the decomposition of which is usually slow on account of low nitrogen and lime. Small amounts of bases released are insufficient to make up the loss against leaching, with the result that these soils develop deficiency in bases with growing age. This arrests further decomposition of the material which tends to accumulate and increases soil acidity. Due to high C : N of litter nitrogen is not released and the soils thus become infertile and bare.
2. *Soils of Class 2.*—These sites receive a mixed litter with a high C : N and high C : bases ratio at some places and with low at others. The decomposition of the first type of litter tends to produce base deficient and infertile soils but as some of the sites of the soils of this class are from coppiced or recently felled areas soil deterioration is checked in this way. Here *Scilla-Pteridium* and *Epilobium* communities spring up.

   In sites receiving litter of a low C : N and low C : bases ratio plant material decomposes to give both lime and nitrates, allowing the growth of *Scilla—Rubus*, *Epilobium* and in some cases *Urtica* communities. These soils are not very base deficient and contain sufficient amounts of nitrates.
3. *Soils of Class 3.*—The litter here is always of a low C : N and low C : bases ratio the decomposition of which produces large amounts of bases and nitrates. Thus a high base status and fertility of these soils is maintained. Bases liberated tend to lower soil acidity. Here nitraphilous plants like *Mercurialis*, *Mercurialis-Urtica* and *Brachypodium* are abundant.

Biological Classification of the Soil Types

According to the biological classification of soils proposed by the Danish botanist Muller soil Type 3 with low organic matter and large worms corresponds to his Mull which I propose to call here 'true mull' to distinguish them from soils of Class 2.

Soils of Class 2 with moderately low organic matter content between 7–10% and fewer worms may be termed 'Mull'.

Soils of Class 1 with high organic matter and no worms would certainly correspond to 'Transition to mor' soils.

The plant communities growing on these three types of soils may be taken as indicator communities. Thus, true mull supports *Mercurialis*, *Mercurialis-Urtica*, *Brachypodium* and *Urtica* communities. On mull soils grow *Epilobium*, *Scilla-Rubus* and *Scilla-Pteridium* communities. 'Transition to mor' soils coincide with bare areas.

Evidence produced here shows that tree vegetation, topography, and worms are the principal factors which determine the type of

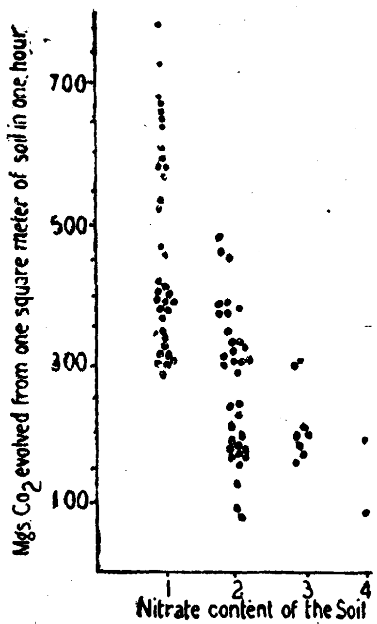

Fig. 10

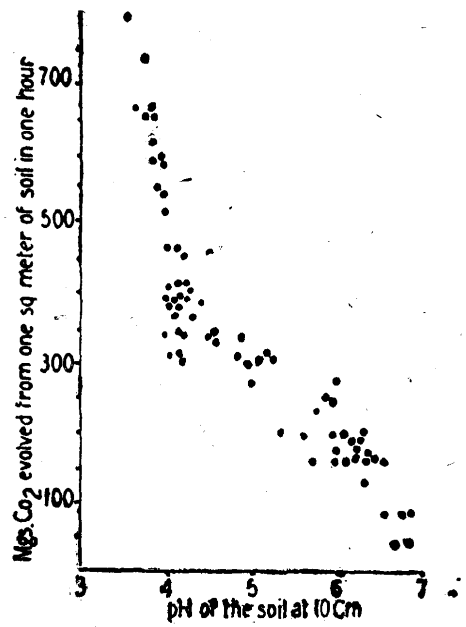

Fig. 11

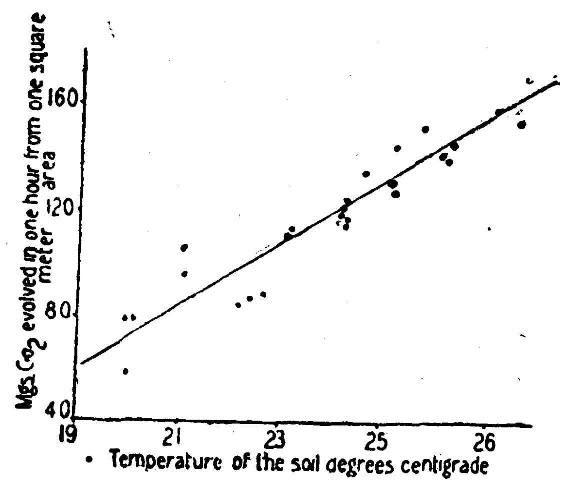

Fig. 12

forest soils in these woods. Our observations are thus in agreement with Muller, who laid particular stress on tree vegetation and soil flora and fauna in determining the type of forest humus.

The low amounts of organic matter in true mull soils is due to the activities of worms and faster bacterial decomposition. High amounts in transition to mor soils is related with the absence of worms and slower decomposition. These results agree with observations of Hesselman (1917, 1926) and Falck who advocate that the role of tree vegetation in creating different types of forest humus is mainly concerned with the different chemical composition of the litter. This litter according to them decomposes at different rates—rapid in mull and slow in mor soils.

Higher fertility of mull soils as compared to mor is due to the abundance of nitrates in the former which is derived from the decomposition of organic matter of a low C : N ratio. Pearsall (1938) has similarly shown that in the North England woods nitrates are abundant in mull soils, mor soils normally lacked nitrates.

Thus, it follows that soil types can be classified on the basis of plant communities which they bear.

SOIL TYPES AND REGENERATION OF FOREST TREES

The failure of regeneration of forest trees, e.g., oak, beech, ash, etc., in English woodlands is regarded by some ecologists (see Tansley, 1939) to be largely due to one or the other of the following factors :—

1. Injury caused to seeds by rodents, rabbits, birds, moles, insects, etc.
2. Attacks by parasites and fungi.
3. Destructive effect on seedlings of grazing, etc.
4. Dry climate.
5. The absence of a film of water round nuts of beech, which consequently fail to germinate.
6. Low light intensity under beech, box and yew trees.
7. Straggling effects of *Rubus fruticosus* on tree seedling.
8. Periodicity of mast years, etc.

In the Whippendell woods, there was a considerable amount of regeneration. Similarly, in other examples studied, e.g., the beech woods at Tring, at Box Hill, regeneration of forest trees was quite considerable. It would, therefore, appear that the above factors do not either operate or are inaffective in these woods. Irregular canopy and rarity of seeds seemed to be favourable for regeneration in most cases.

The data presented in these papers seems to show that the distribution of tree seedlings like ground flora communities is closely related to soils types. Thus, the greatest number of seedlings were found on true mull soils, but the number of tree seedlings on 'transition to mor' soils, in these woods was very small.

Ash and hazel are found to regenerate best on true mull soils. Oak, hornbeam, hawthorn, beech occur predominantly on mull. True mull soils, with high base status, high pH and high nitrates, seem to be too rich for these species. Sycamore seems to have a greater ecological amplitude and occurs both on true mull and mull, though it is more common on mull soils.

A few seedlings of beech, birch, hawthorn, etc., were seen on 'transition to mor' soils but they suffered badly after the first year.

Pearsall (1938) has pointed out that in North England woods ash and oak regenerate on mull soils. On mor soils seedlings were those of pine, birch and of *Pyrus aucuparia*. My own limited data from North England woods (Puri, 1949*a*, 1949*b*) bears out Pearsall's observation.

Above consideration lead to the conclusion that the regeneration of forest tree species in the examples studied is closely related to soil types. Thus, it appears that the knowledge of the relationship between the soil types and tree seedlings is of vital importance for successful silvical operations in forestry.

PROBLEMS OF SOIL FERTILITY AND FOREST REGENERATION

From the foregoing it follows that (1) tree vegetation exercises a great influence on soil fertility and (2) forest regeneration is closely related to soil fertility.

Under the influence of damp climate in this country soil minerals, like lime, are constantly

leached out of the surface layers of the soil, tending to make them with advancing age base deficient and infertile. Tree vegetation as a whole tends to militate against this trend of soil deterioration by absorbing minerals from deeper layers and returning them to the surface in a forest. Thus, in this struggle against constant degradation of the soil, plants with deep feeding roots and those with greater lime requirements are most effective. Ash, Hazel, lime, elm, and to some extent sycamore belong to this category, and depending upon the mineral content of the substrate tend to maintain or sometimes even increase base status of the surface layers of the soil. Trees like pines, birch and chestnut with low mineral requirements do not replenish the loss of minerals against leaching and are, therefore, harmful for the soil, especially in poor and sandy places. Oak, hornbeam, though intermediate in their lime requirements may, nevertheless, be classed with the second category of plants.

Thus, with respect to their effect on soil minerals our common woodland species may be broadly grouped in two categories and their effect on soil may be summed up as under :—

A. *Non-exacting species.*—Pine, birch, chestnut, beech, hornbeam.

(1) These are largely ineffective against loss of minerals by leaching.

(2) Their litter being poor in bases is not eaten by worms and decomposes slowly.

(3) The slowly decomposing material produces more organic acids and CO_2 which make the soil acid and further help in the dissolution of soil bases. This further retards the decomposition and under these conditions organic matter tends to accumulate.

(4) Soil acidity, high content of organic matter, base deficiency and absence of nitrates combine to make the soils infertile and check the germination and establishment of tree seedlings.

(5) Under extreme conditions such soils develop podsol profile with an impervious pan layer of humus, silica or iron. The roots of trees are unable to pierce through this layer and unless the layer is broken the soil becomes permanently useless for reafforestation purposes. Podsol profiles are characteristic of northern coniferous forests.

B. *Exacting species.*—Ash, hazel, lime, elm, sycamore.

(1) These on the other hand, are able to militate against soil deterioration by bringing on the surface minerals from deeper layers. In this way they maintain and in some cases increase base status of the soil.

(2) Lime-rich litter is readily eaten by worms, which bring mineral rich soil in their casts on the surface and further help in increasing soil fertility.

(3) The litter is rapidly decomposed, thereby releasing great quantities of mineral and plant foods.

(4) In rapid decomposition there is no increase in acidity, but bases released usually increase soil pH. The abundance of nitrates, low organic content, high base status makes the soil fertile and induces the regeneration of forest trees.

(5) These soils in their extreme development show a brown earth type of profile which is characteristic of deciduous forests.

It is clear that for successful regeneration of forest trees in this country soils with mull type of humus layer and brown earth profiles are suitable and must be left under forests of exacting species. The forest vegetation of the greater part of Britain is geographically related to the deciduous forests of the Continent, and it should include mixed woodlands of exacting and non-exacting angiospermic species.

The planting of conifer in this region is detrimental, amounting to accelerating the natural process of soil deterioration and making it unfit in the course of ages for growth of any tree species. It is of the utmost importance, therefore, that in any scheme of reafforestation this dynamic relation between plant and the soil, which affects the soil fertility and forest regeneration be borne in mind. For successful

establishment of tree seedlings soil of suitable properties is essential.

CONCLUSIONS AND SUMMARY

On the basis of characteristic ground flora communities and associated tree seedlings, humus layer in the Whippendell woods was classified into three main types, corresponding broadly to Muller's well recognized biological types—Mull, Mor, and type intermediate between the two extremes.

The ground flora communities and seedling growth in these woods was found to be intimately related to the whole complex of soil conditions and not to any single factor, thus confirming Pearsall's conclusions about North England woods, and indicating their applicability equally to the woods of South England.

The different types of humus recognized in these woods were found to be related to topography, tree vegetation and worms. Broadly speaking, soils at lower levels were mull, while mor or 'transition to mor' soils were usually observed at upper levels.

Tree vegetation seemed to have a much greater influence on the development of humus layer. By virtue of their capacity to absorb minerals from deeper layers and bringing them to surface of the soil trees on the whole tend to keep minerals in circulation and militate against the loss of leaching. Thus the chemical composition of litter, which determines its palatability to worms and rate of decomposition in nature, assumes great importance in determining humus types. Litter with a high C : N and a high C : bases is not only less readily eaten by worms but its decomposition under natural conditions is slow. Litter of low C : N and a low C : bases, on the other hand; decomposes faster and is palatable to worms. The rapid decomposition of litter releases plant foods (nitrates) and minerals which not only act against soil acidity but maintain a high base status of the soil and produces fertility conditions. The accumulation of litter, on the other hand, increases acidity, accentuates leaching, does not liberate plant foods and so makes the soil infertile. Thus, it follows that trees with high lime requirements and low C : N tend to increase soil fertility forming mull soils, while those with low lime requirements and a high C : N generally result in unproductive conditions and mor soils.

The regeneration of forest trees is intimately related in these woods to soil types and soil fertility. Thus, a greater number of woodland species, e.g., ash, cherry, hazel, oak and even beech grow as seedlings on mull soils. The only species regenerating on mor soils are pine, birch and mountain ash. It, therefore, follows that for a successful establishment of forest trees soil fertility is of the utmost importance. In the damp climate of Britain the general trend of soil development is one of decreasing fertility with advancing age. The importance of species like ash, hazel which maintain soil fertility and conditions for forest regeneration cannot be over emphasised for successful forestry practices in this country. The danger of planting conifers is obvious.

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Dr. L. G. Romell of the Experimentalfaltet, Sweden went through this paper and suggested considerable improvements, which in the absence to the author of Swedish, Danish, French and German literature have been extremely useful. For obvious reasons, it has not been possible to refer to many foreign works in the bibliography and Dr. Romell has very kindly checked my results with known literature on the subject. From the following extract from Dr. Romell's private communication dated 19th March 1948, it will be clear that the results given in the paper are of a general nature for European forests. He writes, "His (Puri's) conclusions dovetail in a most interesting manner with observations made in this country as to the nutritional requirements of tree species and with observational and other data showing the level of nutrients to vary with topography and slope—exactly in the way concluded by Dr. Puri from his studies. It seems that Dr. Puri's work has yielded a most satisfactory, simple and natural explanation to the actual distribution of tree species within the areas that he has studied".

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APPENDIX I

Analysis of soil samples and details of ground vegetation from the Whippendell woods

Quadrat No.	Ground Vegetation	pH	Thiocyanate	Nitrate	Water content	Loss on ignition	R.H.	Worms observed	Tree seedlings
	TRANSECT I:—								
1	*Rubus fruticosus, Scilla* ..	3·87	3	0	42·0	14·0	3·0	W	Hawthorn.
2	Bare area	3·99	2	1	27·0	8·8	3·0	..	Beech.
3	*Rubus idæus*	5·45	1	1	25·0	8·8	3·1	W	Beech, Hornbeam.
4	*Urtica dioca—Mercurialis perennis.*	7·82	0 Ca	2	37·5	12·0	..	W	Ash, Ash.
5	*Arum maculatum, Mercurialis,*	5·64	0	2	28·2	5·1	5·5	W	Hawthorn.
6	*Scilla, Rubus*	4·80	1	1	32·6	7·9	4·1	..	
7	*Mercurialis, Circæa lutetiana* ..	5·78	1	1	30·8	5·3	5·8	W	Ash.
8	*Urtica, Lychnis dioca* ..	6·56	0	1	..	..	..	W	
9	*Mercurialis, Ajuga reptans* ..	5·39	0	1	23·7	3·6	6·5	W	Ash.
10	*Mercurialis*	5·23	0	2	32·1	5·5	5·8	W	
11	*Scilla, Chamanerion angustifolium.*	4·92	0	1	..	..	..	..	
12	*Chamanerion, Urtica* ..	4·89	1	2	25·9	6·8	3·8	..	
13	*Scilla, Rubus, Thuidium tamariscinum*	4·56	2	2	32·4	6·6	4·9	..	Sycamore, Beech.
14	*Scilla, Rubus*	5·18	0	1	28·4	6·1	4·6	..	
15	*Scilla*	4·22	2	1	31·8	9·2	3·4	..	Sycamore.
	TRANSECT II:—								
16	Bare area	4·00	3	1	50·3	18·4	2·7	..	Beech, Hawthorn.
17	*Scilla, Rubus*	4·51	2	2	31·0	7·6	4·0	..	Beech, Hawthorn.
18	*Scilla, Rubus, Urtica* ..	4·84	1	2	33·5	8·2	4·0	..	Beech, Hawthorn.
19	*Rubus, Chamænerion* ..	4·97	1	1	32·4	7·4	4·3	..	
20	*Mercurialis*	5·38	0	2	36·7	6·4	5·7	W	Ash.
21	*Brachypodium sylvaticum, Circæa*	5·10	1	2	25·0	4·4	5·6	W	Ash, Beech.
22	*Mercurialis, Brachypodium, Fragaria*	5·55	0	2	32·2	7·6	4·2	W	Ash, Hawthorn.
23	*Scilla, Pteridium aquilinum, Rubus*	4·21	2	1	34·0	6·6	5·1	..	
24	*Rubus, Scilla*	4·68	1	2	35·3	8·7	4·0	..	
25	*Scilla, Lychnis*	4·62	1	1	33·5	7·4	4·5	..	
26	*Urtica, Mercurialis* ..	5·99	0	2	30·1	7·7	3·9	..	
27	*Mercurialis, Fragaria, Lychnis* ..	5·12	1	2	34·9	9·6	3·3	W	Ash.
28	*Fragaria, Ajuga reptans* ..	4·64	1	1	37·0	6·5	5·6	W	
29	*Mercurialis, Urtica, Circæa* ..	5·32	0	2	35·7	7·5	4·7	..	Ash.
30	*Chamanerion, Rubus* ..	4·97	1	2	33·9	8·8	3·8	W	Ash.
31	*Rubus, Mercurialis* ..	5·11	0	2	24·1	5·6	4·3	..	Sycamore, Ash Ash.
32	*Scilla*	4·88	1	2	41·5	12·2	3·3	..	Sycamore, Ash.
33	*Scilla—Pteridium*	4·62	1	1	43·7	13·8	3·1	..	Sycamore.
34	*Scilla*	5·12	1	1	24·1	5·5	4·3	..	Beech, Sycamore.
35	*Chamanerion, Rubus, Scilla* ..	4·28	2	1	39·2	15·8	2·4	..	Beech.
36	*Scilla*	4·75	1	1	42·5	12·9	3·3	..	Cherry.
37	*Mercurialis, Rubus* ..	4·78	1	2	40·7	11·8	3·4	..	
38	*Mercruialis, scilla*	5·44	1	2	28·0	7·0	4·0	..	
	TRANSECT III:—								
41	*Scilla, Chamanerion* ..	4·32	3	2	38·9	10·4	3·7	..	Hawthorn.
42	*Scilla—Rubus*	4·80	1	1	45·5	12·5	3·6	..	
43	*Rubus*	4·63	2	2	34·0	6·2	5·4	..	Beech, Ash.

(*contd.*)

APPENDIX I—(*contd.*)

Quadrat No.	Ground Vegetation	pH	Thiocy-anate	Nitrate	Water content	Loss on ignition	R.H.	Worms observed	Tree seedlings
	TRANSECT III :—								
43*a*	*Rubus* ..	4·72	1	1	41·8	13·8	3·0	..	Ash.
44	*Brachypodium, Circœa* ..	6·58	0 Ca	3	25·7	3·9	6·5	W	Ash.
45	*Mercurialis, Arum, Taraxacum*	7·90	0 Ca	3	38·1	12·2	..	W	Ash.
46	*Mercurialis, Brachypodium* ..	6·23	0	3	..	..	..	W	Ash.
47	*Euphorbia amygdalloides, Mercurialis*	5·12	1	2	28·7	4·2	6·8	W	Ash.
48	*Rubus, Scilla, Galium, Epilobium*	4·82	1	2	40·5	13·2	3·0	..	
49	*Scilla, Rubus*	4·26	2	2	33·0	9·7	3·4	..	
50	*Mercurialis, Urtica, Circœa* ..	5·23	0	4	23·8	3·5	6·8	W	
51	*Mercurialis, Geum urbanum* ..	5·19	0	4	22·8	2·6	9·1	W	Ash.
52	*Mercurialis, Circœa, Urtica* ..	5·29	0	3	25·5	3·3	7·7	W	
53	*Mercurialis, Circœa* ..	5·21	1	3	27·6	2·0	13·8	W	Ash.
54	*Mercurialis, Circœa* ..	5·11	1	3	23·3	5·2	4·4	W	Ash.
55	*Circœa, Ajuga, Geum* ..	5·42	0	1	36·3	4·0	9·0	W	Ash.
56	*Mercurialis, Urtica, Circœa* ..	5·25	0	2	38·0	6·3	5·5	W	
57	*Rubus, Chamanerion, Pteridium*	4·66	1	3	34·8	7·8	4·4	..	
58	*Pteridium, Chamanerion* ..	4·08	2	2	38·9	15·6	2·4	..	Beech.
59	*Scilla, Oxalis acetosella* ..	4·79	1	1	47·3	12·3	3·8	..	Cherry.
60	*Scilla* ..	4·29	1	1	..	..	..	..	
61	*Scilla, Pteridium, Rubus* ..	4·18	2	1	51·8	15·6	3·3	..	Holly Beech.
62	*Scilla, Oxalis*	4·60	2	2	38·2	8·5	4·4	..	Sycamore.
63	*Scilla, Oxalis, Rubus* ..	4·19	2	1	54·2	17·8	3·0	..	
64	*Pteridium, Rubus, Chamaenerion*	4·86	1	1	38·8	12·7	3·0	..	Beech.
66	*Chamaenerion, Rubus* ..	4·87	1	2	..	..	..	..	
67	*Rubus*	4·84	1	1	39·5	11·2	3·4	..	
68	*Rubus, Chamaenerion* ..	4·75	1	1	..	..	..	..	Beech.
	TRANSECT IV :—								
69	*Rubus, Nepeta*	5·99	1	1	..	..	..	..	Ash.
69*a*	Bare area	4·09	2	1	35·4	9·0	3·9	..	Holly.
70	*Mercurialis, Fragaria* ..	4·94	1	2	27·8	4·3	6·4	..	Ash.
71	*Rubus, Fragaria*	4·86	1	1	..	..	..	..	Hawthorn.
72	*Mercurialis*	8·26	0 Ca	2	37·6	16·2	..	W	Ash.
73	*Mercurialis*	7·99	0 Ca	3	31·8	15·2	..	W	Ash, Hazal.
74	*Mercurialis, Geum, Fragaria* ..	7·61	0 Ca	2	33·5	14·8	..	W	Ash.
75	*Mercurialis—Urtica, Viola* ..	8·21	0 Ca	3	36·7	15·5	..	W	
76	*Urtica, Chamœnerion* ..	5·74	0	3	33·3	6·6	5·0	W	Howthorn.
77	*Scilla, Rubus*	4·14	2	2	..	..	..	..	
78	*Rubus, Scilla*	4·73	1	1	45·5	11·6	3·8	..	
79	*Rubus, Chamœnerion* ..	4·71	2	1	22·5	4·2	5·3	..	
80	*Mercurialis, Scilla—Rubus* ..	4·86	1	2	37·4	13·5	2·7	..	
81	*Mercurialis, Geum, Circœa* ..	5·36	0	3	27·3	5·0	5·4	W	Ash.
82	*Chamœnerion, Rubus* ..	4·81	1	1	..	..	..	..	Beech, Hawthorn.
83	*Rubus, Chamœnerion, Urtica* ..	4·97	1	2	..	..	..	..	
84	*Scilla-Rubus*	4·17	2	2	28·5	8·0	3·5	..	Hawthorn.
85	*Chamanerion, Rubus* ..	4·75	1	2	..	..	..	..	Hawthorn, Beech.
86	*Scilla, Rubus*	4·00	2	1	36·2	12·5	2·9	..	
87	*Scilla, Rubus*	4·68	1	2	30·2	7·4	4·0	..	Birch, Hawthorn.
88	*Chamanerion, Scilla, Oxalis,* ..	5·00	1	3	29·8	5·8	5·1	W	
89	*Rubus, Circœa*	4·22	1	3	25·4	7·0	3·6	..	Sycamore, Birch.
90	*Rubus, Circœa, Lonicera* ..	5·14	1	1	48·4	9·7	4·9	W	Sycamore, Ash.
91	*Chamanerion, Rubus* ..	4·58	1	2	28·8	6·9	4·1	..	Sycamore, Beech.
92	*Rubus, Oxalis*	4·42	2	3	24·6	6·5	3·7	..	Sycamore, Beech.
93	*Rubus*	4·64	1	3	23·9	5·3	4·5	..	Sycamore, Ash.

(*contd.*)

APPENDIX I—(*concld.*)

Quadrat No.	Ground Vegetation	pH	Thiocyanate	Nitrate	Water content	Loss on ignition	R.H.	Worms observed	Tree seedlings
	TRANSECT V :—								
94	*Rubus, Pteridium*	5·12	1	1	52·0	8·0	6·5	..	Cherry.
95	*Rubus, Pteridium*	4·31	2	1	..	..	..	..	Beech.
96	*Rubus, Pteridium*	3·86	3	1	51·7	19·2	2·6	..	Beech.
97	*Rubus*	5·08	1	2	30·2	5·0	6·0	..	Ash.
98	*Rubus, Mercurialis, Circœa* ..	5·84	0	2	34·6	4·6	7·5	W ..	Ash.
99	*Mercurialis, Arum, Fragaria* ..	5·94	0	2	..	..	..	W	
100	*Mercurialis—Urtica* ..	8·45	0 Ca	2	27·7	8·0	..		
101	*Mercurialis, Urtica, Chamanerion*	6·01	0	2	..	..	..	..	
102	*Chamanerion, Scilla, Lychnis* ..	4·94	1	2	..	..	..	..	Beech. Cherry,
	TRANSECT VI :—								
103	*Chamanerion, Lychnis, Urtica, Rubus*	4·12	1	3	30·0	9·0	3·3	..	Birch.
104	Bare area	3·92	3	1	..	..	..	..	Beech.
105	*Viola, Fragaria, Teucrium* ..	4·83	1	2	..	..	..	..	Birch.
106	*Mercurialis, Urtica, Rubus* ..	5·94	0	1	35·6	4·6	7·7	..	
107	*Mercurialis—Urtica* ..	5·81	0	1	30·9	16·3	4·9	..	
108	*Mercurialis—Urtica* ..	8·31	0 Ca	2	45·0	14·0	..	W	Ash.
109	*Rubus*	4·38	1	2	33·7	6·9	4·8	..	Ash.
110	Bare area	3·84	3	1	63·1	19·9	3·1	..	
111	*Rubus, Teucrium, Chamanerion*	4·78	1	2	31·8	10·3	3·0	..	Birch.
	TRANSECT VII :—								
112	*Urtica, Scilla, Rubus* ..	4·94	1	1	25·8	4·6	5·1	..	Hawthorn, Ash.
113	Bare area	3·81	3	0	65·8	19·8	3·3	..	Beech, Birch.
114	*Mercurialis, Circœa, Fragaria*	5·83	0	2	32·5	7·2	4·5	W	Ash.
115	*Teucrium*	4·33	2	1	33·3	6·6	5·0	..	Oak, Birch.
116	Bare area, *Rubus*	3·94	3	1	31·7	13·6	2·3	..	Birch.
117	*Mercurialis, Circœa, Arum* ..	8·52	0 Ca	2	30·3	15·1	..	W	Ash.
118	*Mercurialis*	7·22	0 Ca	2	31·3	5·0	..	W	Ash.
119	*Urtica, Galium, Rubus* ..	4·14	2	3	30·8	8·5	3·6	..	
120	Bare area	3·93	3	1	42·9	16·5	2·5	..	
121	*Mercurialis-Urtica, Galium* ..	5·28	0	2	22·6	5·4	4·1	..	
122	*Rubus, Oxalis*	4·34	1	2	35·5	7·8	4·5	..	
123	*Galium, Circœa, Arum* ..	5·25	0	3	..	..	..	W	Ash, Oak.
124	*Urtica, Chamanerion, Circœa* ..	5·63	0	2	32·3	4·6	7·0	W	
125	*Geum, Thuidium*	5·14	0	2	23·3	6·4	3·6	W	Oak, Ash.
126	*Rubus, Ajuga, Nepeta* ..	5·17	1	2	25·2	6·5	3·8	W	Ash.
128	*Pteridium, Chamanerion* ..	4·06	2	2	26·6	17·3	1·5	..	Cherry.
129	*Pteridium, Chamanerion, Rubus*	4·84	1	2	22·2	9·7	2·2	..	
130	*Rubus, Ajuga, Viola* ..	4·76	1	3	34·3	9·8	3·5	..	Ash.
131	*Rubus*	4·36	1	1	34·7	6·5	5·4	..	Beech.
132	*Rubus, Chamanerion* ..	4·03	2	2	35·8	15·4	2·3	..	Sycamore, Beech.
133	*Chamanerion, Rubus* ..	4·30	1	2	..	..	..	..	Beech, Sycamore.
	TRANSECT VIII :—								
134	Bare area	3·81	3	2	49·8	16·4	3·0	..	Birch, Beech.
135	*Rubus, Chamanerion* ..	5·54	0	3	..	..	..	W	Sycamore.
136	*Mercurialis, Rubus, Circœa* ..	5·32	0	3	..	..	..	..	Ash.
137	*Mercurialis—Urtica* ..	7·24	0 Ca	2	..	..	..	W	Ash.
138	*Mercurialis—Urtica, Circœa* ..	5·01	1	2	25·6	6·8	3·7	..	Ash.
139	*Rubus, Nepeta*	4·60	1	2	..	..	..	..	Ash.
140	*Rubus*	4·08	2	1	29·5	13·6	2·1	..	
140*a*	*Rubus, Scilla*	4·01	2	2	40·1	13·2	3·0	..	Beech.
141	*Mercurialis*	5·21	1	2	19·8	4·0	4·9	..	Ash.

APPENDIX II

Soil pH and number of tree seedlings in quadrats of one square foot area

Quadrat No.	Tree seedlings	Soil pH	Quadrat No.	Tree seedlings	Soil pH
151	Hawthorn (4)	4·92	194	Oak (1)	5·39
152	Oak (1)	5·78	195	Ash (12)	4·68
153	Birch (1)	3·92	196	Ash (20)	4·59
154	Oak (1)	4·86	197	Ash (30)	4·62
155	Oak (2) Hawthorn (3) ..	4·28	198	Ash (11)	4·72
156	Oak (2)	4·72	199	Sycamore (1)	4·74
157	Oak (2)	4·59	200	Sycamore (1)	4·93
158	Oak (1)	5·03	201	Sycamore (1)	5·01
159	Ash (7)	5·11	202	Sycamore (1)	5·06
160	Oak (1)	4·85	203	Sycamore (5)	4·18
161	Ash (5)	4·55	204	Sycamore (3)	4·47
162	Oak (2)	5·71	205	Sycamore (1) Ash (4) ..	4·60
163	Ash (6)	5·49	206	Birch (5)	3·93
164	Ash (20)	6·84	207	Sycamore (8)	4·62
165	Ash (14)	8·62	208	Sycamore (12)	4·13
166	Ash (35)	8·60	209	Sycamore (7)	4·66
167	Ash (20)	8·58	210	Sycamore (5)	4·31
168	Ash (15)	6·10	211	Hornbeam (5)	4·06
169	Ash (19)	6·31	212	Oak (1)	5·82
170	Ash (2)	9·12	213	Hornbeam (1)	4·97
171	Ash (5)	9·00	214	Hornbeam (1)	5·46
172	Hornbeam (2)	5·48	215	Oak (1)	4·60
173	Ash (10)	8·59	216	Hornbeam (1)	4·87
174	Holly (1)	4·52	217	Sycamore (7)	4·67
175	Birch (6)	4·54	218	Sycamore (8)	4·46
176	Birch (2)	4·00	219	Hornbeam (1)	4·42
177	Birch (8) Hornbeam (2) ..	5·18	220	Birch (16)	4·14
178	Oak (1) Ash (4)	4·52	221	Cherry (1)..	4·10
179	Beech (4)	4·23	222	Cherry (2)..	4·52
180	Ash (6)	4·51	223	Cherry (1)..	4·69
181	Beech (2)	4·49	224	Cherry (3)..	5·21
182	Beech (2) Ash (1) Oak (1) ..	4·86	225	Holly (3)	4·21
183	Oak (1) Hornbeam (2) ..	5·22	226	Holly (1)	3·99
184	Beech (3) Ash (3)	5·43	227	Holly (2)	4·12
185	Birch (15)	5·53	228	Holly (1)	5·51
186	Birch (8)	4·89	229	Holly (2)	4·10
187	Birch (32)	4·75	230	Sycamore (2)	4·68
188	Birch (26)	4·79	231	Beech (2)	3·99
189	Birch (15)	4·33	232	Beech (4)	4·21
190	Birch (20)	4·09	233	Beech (3)	5·11
191	Sycamore (4)	4·12	234	Beech (1)	3·82
192	Sycamore (4)	4·06	235	Beech (5)	4·68
193	Sycamore (2)	4·25			

APPENDIX III

Dry weight of litter in grammes from quadrats in the Whippendell woods

No.	Vegetation: Ground flora community	Vegetation: Trees, Shrubs, etc.	Wt. in grammes from one square meter area: Leaves	Twigs	Fruits, etc.	Ground vegetation	Total	Mean
1	Bare area ..	Beech, Hawthorn	1815	855	55	..	2735	
2		Beech	1720	844	36	..	2600	
3		Beech	1753	725	10	..	2488	
4		Beech, Spruce	1698	750	15	..	2463	2385
5		Beech, Spruce	1682	610	52	..	2344	
6		Beech, Hornbeam	1640	620	78	..	2338	
7		Beech, Hawthorn	1066	640	350	..	2056	
8		Beech, Oak	1280	676	89	..	2045	
9	*Mercurialis* ..	Ash, Birch, Oak	1410	910	..	..	2320	
10		Ash, Oak, Cherry	1560	640	..	..	2200	
11		Ash, Hazel, Cherry	1620	565	..	..	2185	1902
12		Ash, Oak, Hazel	1370	534	14	..	1918	
13		Oak, Sycamore	1289	417	25	..	1713	
14		Ash, Hazel, Birch	1300	350	..	..	1650	
15		Oak, Birch, Hazel	976	585	50	..	1611	
16		Ash, Sycamore, Cherry ..	1353	250	..	..	1603	
17	*Brachypodium* ..	Oak, Cherry	1560	670	..	..	2230	
18		Ash, Oak, Birch ..	1435	570	..	..	2005	
19		Oak, Birch, Sycamore ..	1313	410	..	..	1723	
20		Ash, Oak	1050	520	..	..	1570	1601
21		Ash, Hazel, Oak	934	530	26	..	1490	
22		Hazel, Ash, Oak	1240	220	30	..	1490	
23		Birch, Hazel	822	400	..	..	1222	
24		Birch, Ash	715	350	11	..	1081	
25	*Scilla-Rubus* ..	Oak, Birch	1052	826	..	..	1878	
26		Beech	1187	596	50	..	1833	
27		Beech, Oak	1213	450	110	..	1773	
28		Oak, Sycamore	1050	610	..	..	1660	
29		Ash, Oak	1134	515	5	..	1654	
30		Ash, Oak	898	600	9	..	1507	
31		Oak, Sycamore	965	457	..	..	1422	1593
32		Oak, Birch	987	23	11	..	1021	
33	*Mercurialis-Urtica*	Ash, Hazel, Hawthorn ..	1224	610	40	..	1874	
34		Elm, Hazel, Ash	1100	448	..	..	1548	1482
35		Ash, Oak	856	400	..	..	1256	
36		Ash, Oak, Sycamore	1053	197	..	..	1250	
37	*Scilla-Pteridium* ..	Oak, Birch, Chestnut ..	998	618	..	54	1670	
38		Oak, Pine	844	380	..	420	1644	
39		Birch, Oak	840	544	..	244	1608	
40		Birch, Spruce, Oak	840	300	110	670	1520	1440
41		Oak, Spruce, Birch	1300	110	..	80	1490	
42		Birch	470	410	..	428	1308	
43		Sycamore, Larch	1069	155	..	75	1299	
44		Oak, Birch, Spruce	782	104	..	100	986	
45	*Chamænerion* ..	Birch, Sycamore	760	640	..	440	1740	
50		Larch, Oak	1122	425	15	100	1662	
51		Beech, Birch	544	155	95	564	1358	
52		Birch	916	302	21	96	1335	1327
53		Birch, Oak	850	300	..	80	1230	
54		Open coppied area	345	600	..	250	1195	
55		Coppied area	110	713	75	168	1066	
58		Birch, Sycamore	617	208	..	225	1050	

APPENDIX IV

Changes in pH in air dried soil samples (of different organic content) on addition of 6–8 c.c. of distilled water.

Ground flora	Soil Sample: Mer-curialis	Mer-curialis	Bare area	Calluna	Bare area
	7·50	5·79	4·08	3·74	3·26
	7·52	6·00	4·00	3·77	3·42
	7·35	6·07	3·94	3·85	3·45
	7·64	6·15	4·00	3·81	3·58
	7·68	6·28	4·07	3·86	3·88
	7·72	6·36	4·21	3·89	3·85
	7·70	6·20	4·26	3·93	3·98
	7·78	6·48	4·27	4·00	4·00
	7·81	6·54	4·32	4·06	3·99
	7·68	6·50	4·42	4·19	3·82
	7·72	6·52	4·42	4·21	3·86
	7·86	6·54	4·28	4·30	3·81
	7·96	6·58	4·43	4·33	3·89
	7·99	6·53	4·38	4·33	3·93
	8·00	6·57	4·39	4·30	3·97
	7·99	6·60	4·48	4·28	3·98
	8·04	6·55	4·52	4·26	3·89
	8·06	6·59	4·52	4·34	3·99
	8·06	6·61	4·56	4·35	3·89
	8·14	6·61	4·60	4·44	3·99
	8·22	..	4·61	4·50	3·99
	8·28	..	4·61	4·32	
	8·24	..	4·62	4·27	
	8·24	..	4·62	4·37	
			4·63	4·44	
			4·63	4·50	

APPENDIX V

Analysis of Worm Casts

Sample No.	pH	Moisture Content	Loss on Ignition	Relative Humidity
1	6·48	41·0	5·3	7·7
2	6·83	40·6	4·5	9·0
3	7·03	38·9	5·8	6·7
4	6·74	40·0	5·7	7·0
5	6·94	45·8	8·2	5·5
6	7·02	43·2	7·2	6·0
7	7·47	38·1	9·0	4·2
8	7·34	41·0	6·1	6·8
9	7·32	39·5	7·5	5·2
10	7·30	30·5	5·0	6·1

APPENDIX VI

pH of worms casts and soil samples in which worms were living in the laboratory.

	1	2	3	4
pH of soil samples..	6·20	5·27	6·96	7·20
	5·60	5·55	7·10	7·20
		5·76		
		5·90		
pH of worm cast samples ..	6·86	6·47	6·48	7·68
	6·98	6·60	6·74	8·22
	7·18	6·76	6·83	7·94
	7·20	6·96	6·93	7·83
	7·27	6·96	7·00	7·91
	7·35	7·00	7·02	7·88
	7·40	7·02	7·03	7·98
	7·42	7·08	7·30	8·00
	7·44	7·12	7·32	7·24
	7·44	7·23	7·34	7·83
	7·53	7·23	7·47	
	7·61	7·25		
	7·64	7·27		
	7·72	7·34		
		7·42		
Mean soil pH ..	5·90	5·62	7·03	7·20
Mean pH of worm casts ..	7·28	7·06	7·68	7·85
Difference in pH ..	1·38	1·44	0·65	0·65

APPENDIX VII

Changes in pH during laboratory decomposition of 5 gms. of dry powered leaf material in 2 gms. of soil

	23	26	30	33	38	40	44	46
Litter								
Cherry	5·52	6·00	5·85	5·83	6·57	5·66	6·22	5·61
Ash	5·10	5·44	5·51	5·19	5·14	5·18	5·34	5·35
Horse Chestnut ..	4·72	5·00	5·48	5·04	5·28	5·28	5·56	5·40
Beech	4·74	4·71	5·47	5·01	4·86	5·06	5·57	5·26
Sycamore	4·47	4·74	4·76	4·56	4·36	4·40	4·56	4·60
Birch	4·49	4·68	4·76	4·63	4·52	4·55	4·88	4·50
Hazel	4·30	4·68	4·48	4·34	4·20	4·37	4·46	4·32
Oak	4·69	4·92	4·84	4·70	4·58	4·68	4·87	4·73
Pine	4·26	4·39	4·73	4·47	4·48	4·59	4·53	4·34
Chestnut	4·02	4·16	4·30	4·11	3·96	4·02	4·19	4·00
Hornbeam	3·67	3·60	3·87	3·67	3·56	3·63	3·74	4·08

Days	64	67	70	77	85	90	97	Average pH
Cherry	7·26	7·92	7·94	7·65	7·26	7·65	..	6·28
Ash	6·58	7·60	7·28	6·50	7·00	7·65	..	6·04
Horse Chestnut ..	6·59	7·49	7·02	7·28	5·26	6·12	7·54	5·97
Beech	5·96	6·85	6·77	6·80	6·37	6·82	..	5·70
Sycamore	5·74	7·10	7·03	7·11	6·44	7·06	..	5·70
Birch	5·79	6·98	6·86	6·81	6·46	6·93	..	5·47
Hazel	5·8	6·80	6·80	6·73	6·49	6·37	6·97	5·31
Oak	5·83	6·25	6·26	5·20	5·46	6·45	6·18	4·96
Pine	4·71	6·32	6·00	5·86	5·88	..	..	4·73
Chestnut	4·80	6·04	5·88	6·19	5·87	..	..	4·46
Hornbeam	4·94	5·87	5·23	4·69	4·69	4·85	5·56	..

APPENDIX VIII

CO_2, pH, and nitrate of soils with litter of named trees and recorded species of ground flora

No.	Ground Vegetation	Tree litter	CO_2 (mgs.)	Soil pH	Soil Nitrate
1	*Mercurialis*	Oak, Sycamore	244	5·98	2
2	*Urtica*	Birch, Sycamore	193	6·25	3
3	*Mercurialis*	Hawthorn	77	6·72	2
4	Bare area	Sycamore	658	3·81	1
5	Bare area	Sycamore	542	3·94	1
6	*Pteridium*	..	408	4·32	1
7	*Scilla*	Sycamore	387	4·31	1
8	*Scilla, Mercurialis*	Sycamore	348	4·52	2
9	*Pteridium*	(dead bracken)	309	4·98	2
10	*Scilla*	Sycamore	271	5·95	2
11	*Chamœnerion*	Larch	244	5·91	2
12	*Pteridium*	(dead bracken)	231	5·71	2
13	*Mercurialis*	Ash, Hazel	193	5·99	4
14	*Viola*	Hazel	309	5·01	3
15	*Brachypodium*	Larch	348	4·49	1
16	*Brachypodium*	Larch, Sycamore	155	6·32	2
17	Bare area	Sycamore	408	4·25	1
18	*Mercurialis*	Oak, Hazel	193	6·19	3
19	*Mercurialis*	Oak, Birch	77	6·81	2
20	*Mercurialis*	Oak, Ash	193	6·22	3
21	Bare area	Birch	797	3·52	1
22	Bare area	Birch	735	3·64	1
23	*Pteridium*	Oak, Chestnut	585	3·88	1
24	*Pteridium, Epilobium*	Birch, Oak	464	4·00	2
25	Bare area	Birch, Pine	658	3·75	1
26	*Chamanerion*	(dead bracken)	155	6·01	2
27	*Pteridium*	(dead bracken)	387	4·20	1
28	*Urtica*	Birch	77	6·50	2
29	*Mercurialis*	Larch, Ash	122	6·29	2
30	*Brachypodium*	Larch	309	5·18	1
31	*Urtica-Mercurialis*	Sycamore	193	6·01	3
32	*Scilla*	Sycamore	155	6·19	2
33	Bare area	Larch, Sycamore	408	4·20	1
34	Bare area	Larch, Birch	585	3·90	1
35	*Pteridium*	(dead bracken)	662	3·60	1
36	Bare area	Pine	309	4·09	1
37	Bare area	Pine	370,	4·21	1
38	*Teucrium*	Birch, Oak	332	4·10	2
39	Bare area	Pine	224	4·02	1
40	Bare area	Beech	619	3·87	1
41	*Arum*	Hawthorn	585	3·99	1
42	Bare area	Beech	464	4·01	1
43	*Urtica-Mercurialis*	Sycamore, Beech	155	6·30	3
44	*Brachypodium*	Beech	309	5·21	1
45	*Mercurialis*	Ash	39	6·87	3
46	*Mercurialis*	Ash	155	5·98	2
47	Bare area	Birch, Ash, Hazel	658	3·82	1
48	*Pteridium*	Oak	309	4·13	1
49	*Pteridium*	Birch, Beech	348	3·99	1
50	Bare area	Pine	387	3·98	1
51	Bare area	Beech	542	3·95	1
52	Bare area	Beech	270	4·21	1
53	*Mercurialis, Urtica*	Hazel	155	5·99	2
54	*Brachypodium*	Hawthorn	193	5·59	2
55	*Chamanerion*	Oak	387	4·18	2
56	Bare area	Beech	408	3·99	1
57	*Mercurialis*	Hawthorn	154	5·62	3
58	*Scilla, Mercurialis*	Ash	309	4·80	3
59	Bare area	Beech	387	4·11	1
60	*Rubus, Brachypodium*	Oak	464	4·00	2

SIMPLE CALCULATIONS IN THE DESIGN OF FOREST BRIDGES OF STOCK SPANS OF 15, 20, 30 AND 40 FEET

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PART IV

(*Continued from the* "Indian Forester", *October 1950, page 445*)

Design for a timber bridge of span 30 feet, width 10 feet to take I.R.C. 'B' Class loading timber used being sal (*Shorea robusta*). Grade of timber being structural No. 2 conforming to standard grade.

From Figs. 41, 42 and 43 we find that

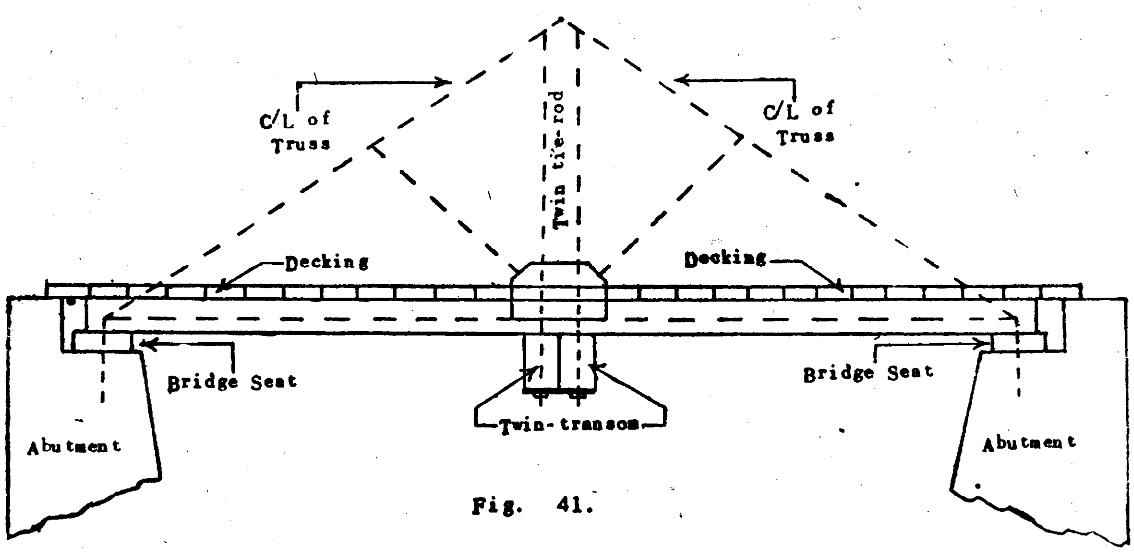


Fig. 41.

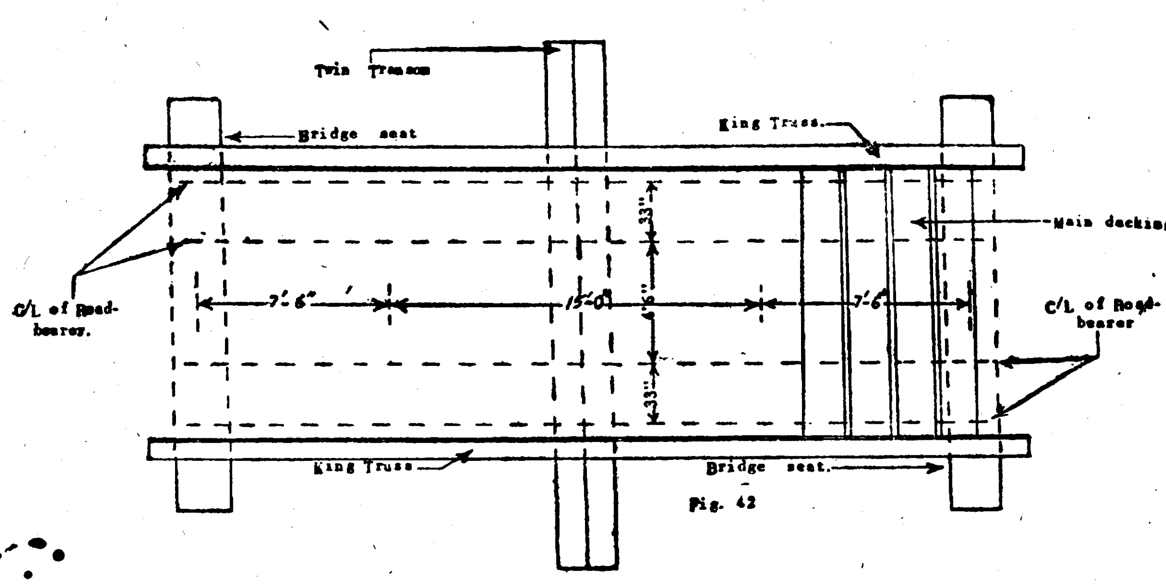


Fig. 42

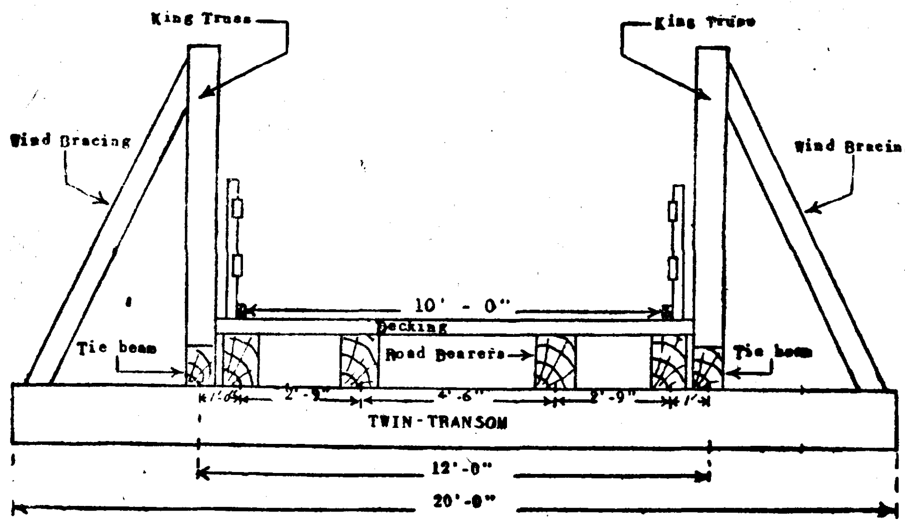


Fig. 43.

(1) No. of roadbearers remain same as in the case of 15 feet span bridge.

(2) Distances between roadbearers also same as that in case of a 15 feet span bridge.

(3) Due to introduction of the middle twin-transom (see Figs. 1 and 2) span of each roadbearer becomes 15 feet.

Design of decking :—

Due to symmetry of spacing of roadbearers and span of roadbearers remaining same (i.e., 15 feet) as in the case of the 15 feet span bridge previously calculated for and sizes arrived at therefore

(1) size of decking remains unaltered, i.e., 2·75 inches thick main decking and over it at right angles place planks $1\frac{1}{2}$ inches thick nailed down to main decking to take wear and tear of traffic. The upper $1\frac{1}{2}$ inches planks can be renewed ; method of placing the wearing deck as shown in Fig. 36, Part III.

(2) size of roadbearers remains unaltered, i.e., section of roadbearers $13'' \times 6''$.

Note.—For calculation of decking and roadbearers refer previous article on design of 15 feet span timber bridge.

Design of twin-transom :—See Fig. 44.

The position of twin-transom 'T_2' and nature of loads on it is as shown in Fig. 44. The point loads coming on the twin-transom through the roadbearers at B, C, E and F in the ratio of their distances apart (Fig. 45*a*), i.e., if we consider the total load as W over the span AG then

(1) Point load at B and F $= \dfrac{1 + 1 \cdot 375}{12} = 0 \cdot 198 \text{ W}$

(2) Point load at C and E $= \dfrac{1 \cdot 375 + 2 \cdot 25}{12} \text{ W} = 0 \cdot 302 \text{W}$

B.M. Computation :—

Only half the dead load of whole structure comes on the central twin-transom.

(1) Dead load of decking coming on central transom

$$= \frac{1}{2}\left(30 \times 10 \times \frac{4 \cdot 25}{12} \times \frac{60}{1} \right) = 3188 \text{ lb.}$$

= twice × 3188 due to prolong duration of dead load

= 6376 lb.

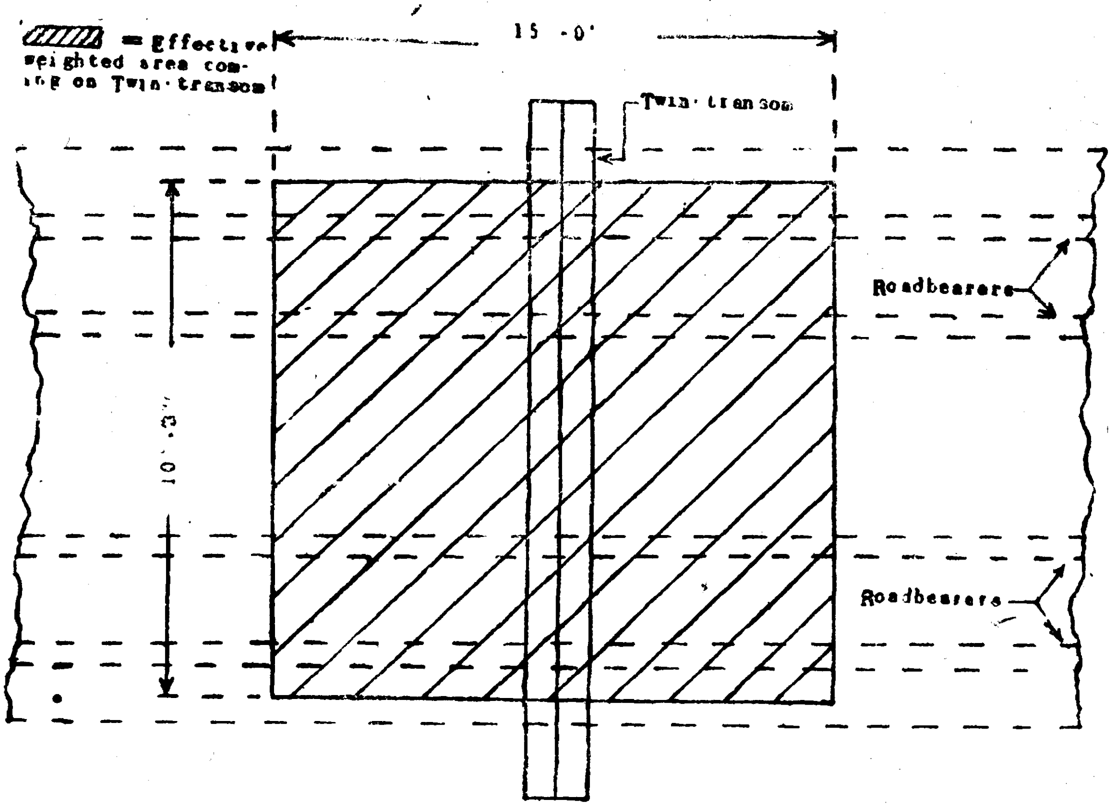


Fig. 44.

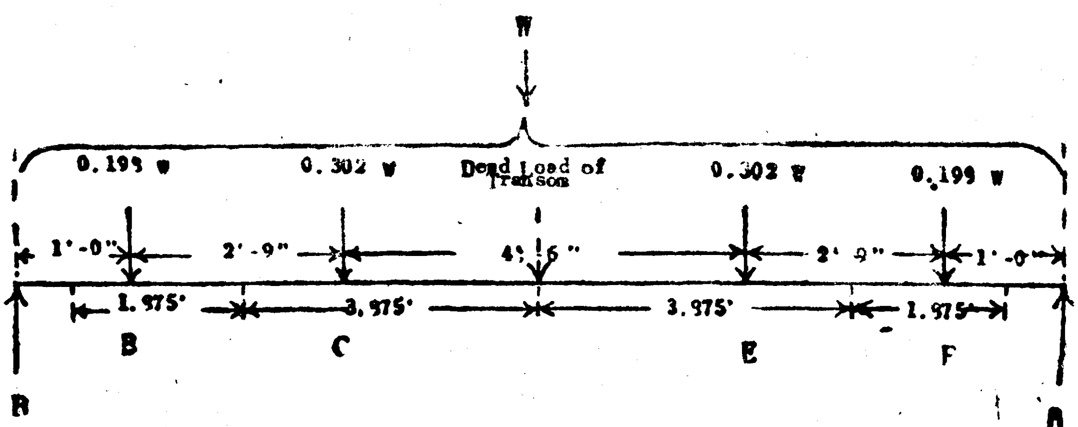


Fig. 45a.

(2) Dead load of 4 roadbearers at points B, C, E and F

= twice × 1950 due to prolong duration of dead load

= 3900 lb.

= 975 lb. dead load of each roadbearer.

(3) Dead load due to its own weight, assuming a section of twin-transom as 14″ × 12″ (i.e., 2 Nos. of each 7″ × 12″) $= \frac{14}{12} \times \frac{14}{12} \times \frac{12}{12} \times \frac{60}{1} = 980$ lb. assuming 14 feet length of transom.

Due to prolong duration the dead weight becomes twice 980 = 1960 lb. acting through C.G. of transom.

(4) Equivalent uniformly distributed dead load due to 0·34 ton per linear foot of each traffic lane coming over central transom = (0·34 × 2240) × 15 = 11424 lb.

(5) Max. load due to 6-ton knife-edge load occurs when knife-edge load comes directly over the central transom and = 6 × 2240 = 13440 lb.

All the loads from (1) to (5) above act on the transom through the points of contact B, C, D, E and F, in the ratio as shown below (Fig. 45*b*).

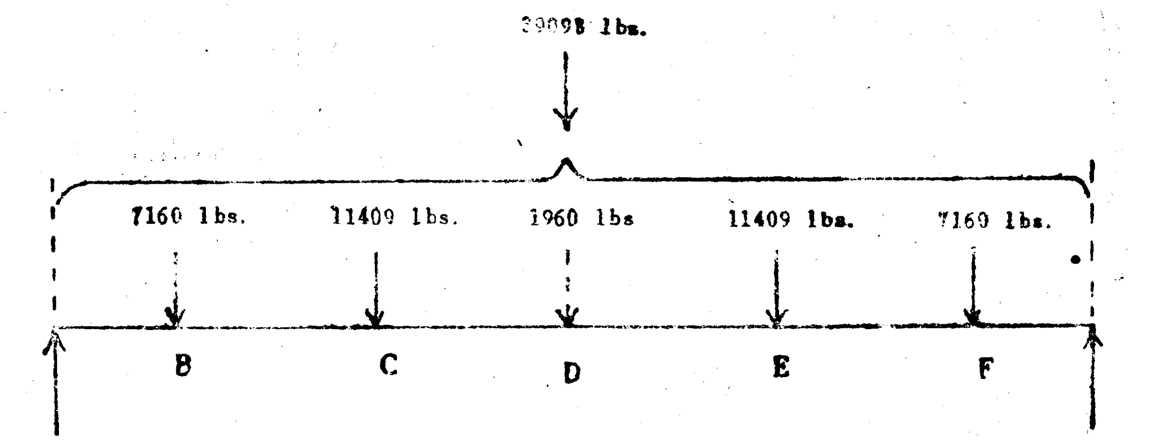


Fig. 45*b*.

At B = 0·198 [(1) + (4) + (5)] + 975
= 0·198 [6376 + 11424 + 13440] + 975
= 0·198 (31240) + 975
= 6185 + 975 = 7160 lb.

At C = 0·302 [(1) + (4) + (5)] + 975
= 0·302 (31240) + 975
= 10434·4 + 975
= 11409 lb.

At D = 1960, i.e., that due to (3)

At E = 0·302 (31240) + 975
= 11409 lb.

At F = 0·198 × 31240 + 975
= 7160 lb.

Total vertical load = 7160 + 11409 + 11409 + 7160 + 1960
= 39098 lb.

∴ Reaction 'R' = ½ × 39098 = 19549 lb.

B.M. at midpoint D = 19549 × 6 − 7160 × 5 − 11409 × 2·25

$B.M._D$ = (see Fig. 46)

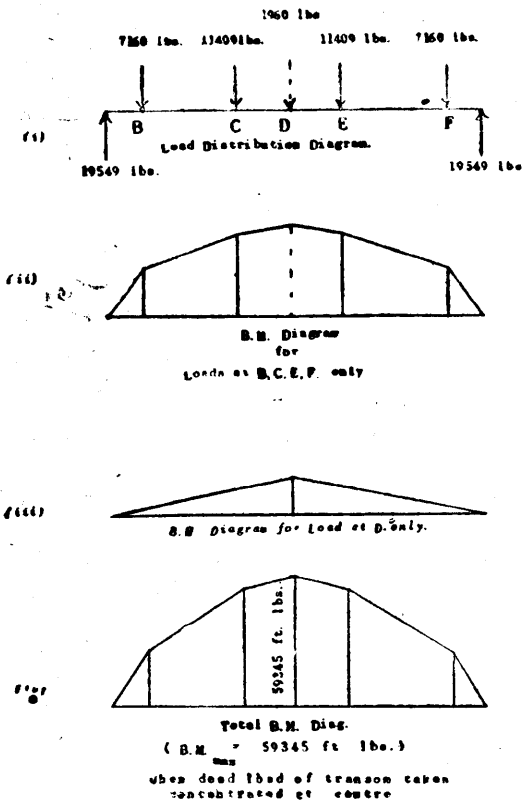


Fig. 45.

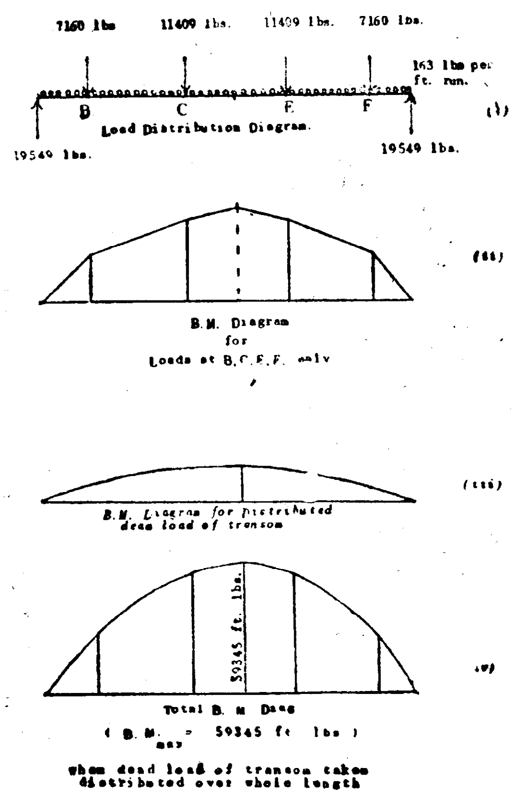


Fig. 46.

$= 59345$ ft. lb.
$= 59345 \times 12$ in. lb.

Now B.M. $= f\,z = f \times \dfrac{bd^2}{6}$

$\therefore\ d^2 = \dfrac{6 \times B.M.}{f \times b}$.

Assuming width of each of the twin-transom to be 5″, we have b = 10″

$\therefore\ d^2 = \dfrac{6 \times 59345 \times 12}{2400 \times 10}$

$d^2 = 170$

$\therefore\ d = 13$ inches.

Hence take each section of the twin-transom to be 5″ × 13″, Fig. 47.

Testing central transom against shear :—

Here the total load is that due to

(1) Portion of decking + U.D.D.L. + Knife-edge + wt. of roadbearers + wt. of transom
$= 3188 + 11424 + 13440 + 1950 + 980$
$= 30982$ lb.

(2) Each one of the twin-transom takes
$\frac{1}{2}\{3188 + 11424 + 1950 + 980\} + 13440$
$= 22211$ lb.

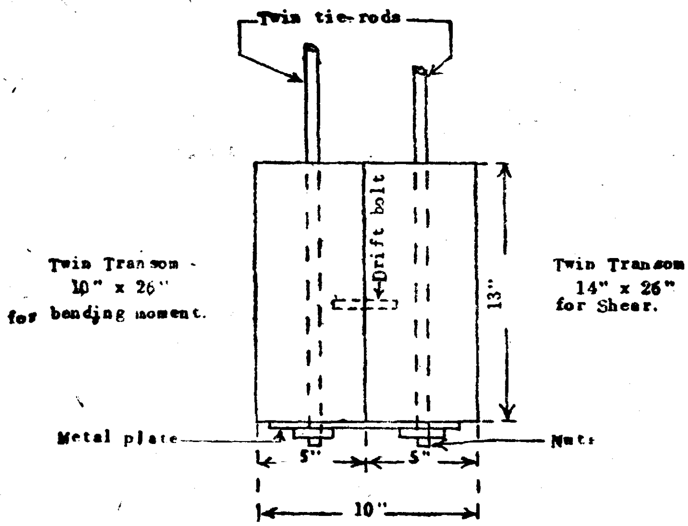


Fig. 47

(3) $\therefore$ Max. shear on each of the twin-transom

$= \frac{1}{2}(22211) = 11105$ lb.

(4) Now average shear $= \dfrac{\text{Max. shear}}{\text{Sectional area}}$

$$\therefore s_a = \frac{s_m}{A}$$

$$= \frac{11105}{(5 \times 13)} = 170 \text{ lb.}$$

(5) Max. intensity of shear stress $= \dfrac{3}{2} s_a$

$$\therefore s_m = \frac{3}{2} \times \frac{170}{1} = 255 \text{ lb. per sq. in.}$$

(6) This actual 's_m' > the allowable 's_m' for sal which is 180 lb. per sq. in. Hence section of each part of the twin-transom will fail in shear.

(7) Try each section of the twin-transom as 7" × 13".

(8) $\therefore s_a = \dfrac{11105}{(7 \times 13)} = 120$ lb. per sq. inch.

(9) $\therefore s_m = \dfrac{3}{2} s_a = \dfrac{3}{2} \times \dfrac{120}{1} = 180$ lb. per sq. inch.

(10) Thus actual s_m = the allowable s_m for sal

$\therefore$ Use a twin-transom consisting of two pieces each of section 7" × 13".

Testing the twin-transom against deflection :—

(1) Dead load of decking corresponding to half the span only $\left(\frac{30}{2} = 15'\right)$ is born by the central twin-transom and $= 15 \times \dfrac{4 \cdot 25}{12} \times \dfrac{60}{1} = 3188$ lb. For design of deflection, dead load is taken three times

$\therefore 3 \times 3188 = 9564$ lb.

(2) Dead load of portion of each roadbearer coming on the twin-transom is

$$\frac{30}{2} \times \frac{13}{12} \times \frac{6}{12} \times \frac{60}{1} \times \frac{1}{1} = 488 \text{ lb.}$$

This acts as a concentrated load at points B, C, E and F, Fig. 48. For design of deflection take three times dead load
i.e. = 3 × 488 = 1264 lb. at B, C, E and F.

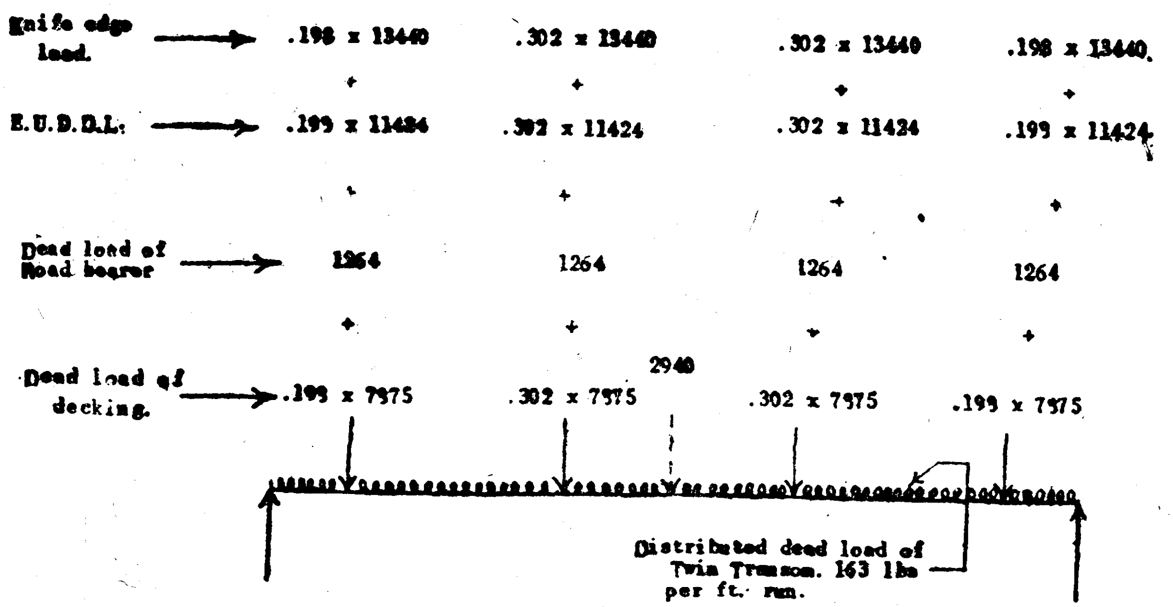


Fig. 49.

(3) Dead load of weight of twin-transom of combined section 14″ × 12″ is

$$\frac{14}{12} \times \frac{12}{12} \times \frac{14}{1} \times \frac{60}{1} = 980 \text{ lb. acting at D.}$$

For design of deflection take three times the dead load,
i.e. 3 × 980 = 2940 lb.

(4) U.D.D.L. due to 0·34 ton per linear foot of each traffic lane over the central twin-transom is

$\frac{1}{2}$ (0·34 × 2240 × 30) = 11424 lb.

This 11424 lb. of weight is acting through points of contact of roadbearers at B, C, E and F in the ratio of

·198 × 11424 at B
·302 × 11424 at C
·302 × 11424 at E
·198 × 11424 at F

= 11424 lb. acting on the twin-transom.

(5) Load due to 6 tons knife-edge load per traffic lane when directly over twin-transom is 6 × 2240 = 13440 lb. acting through points of contact of roadbearers at points B, C, E and F in the ratio of

·198 × 13440 at B
·302 × 13440 at C
·302 × 13440 at E
·198 × 13440 at F

= 13440 lb. acting on the twin-transom.

(6) Hence total load on twin-transom

$$
\begin{aligned}
\text{at B} &= 0{\cdot}198\ (\ 9564 + 11424 + 13440\ ) + 1264 \\
&= (\ {\cdot}198 \times 34428\ ) + 1264 = \ 8079 \text{ lb.} \\
\text{at C} &\doteq 0{\cdot}302\ (\ 34428\ ) + 1264 \ = 11661 \text{ lb.} \\
\text{at E} &= 0{\cdot}302\ (\ 34428\ ) + 1264 \ = 11661 \text{ lb.} \\
\text{at F} &\qquad\qquad\qquad\qquad\qquad = \ 8079 \text{ lb.} \\
\text{at D} &\qquad\qquad\qquad\qquad\qquad \doteq \ 2940 \text{ lb.}
\end{aligned}
$$

(7) Deflection at centre due to a non-central load W_1 is given by (Fig. 49)

$$\delta c = \frac{W_1\, a \times X}{E \times I \times (\ a + b\ )} \times \frac{b^2 + 2\, ab - X}{6}.$$

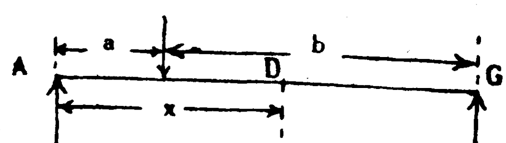


Fig. 49.

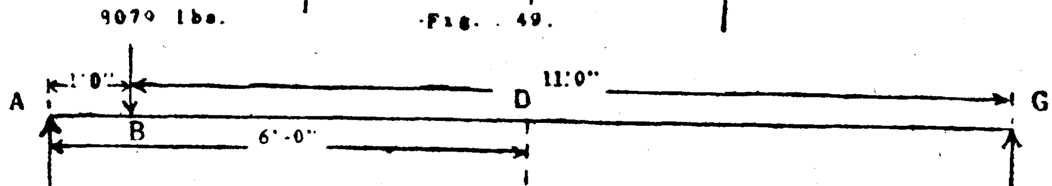


Fig. 50.

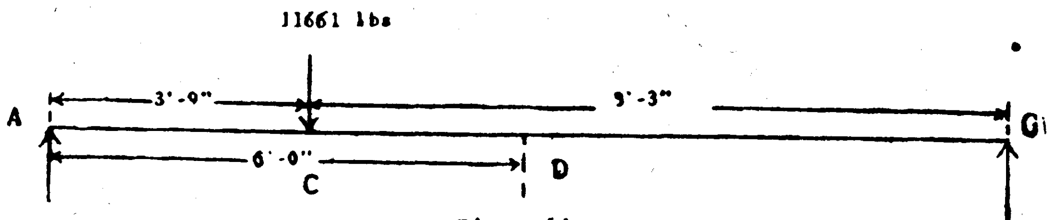


Fig. 51

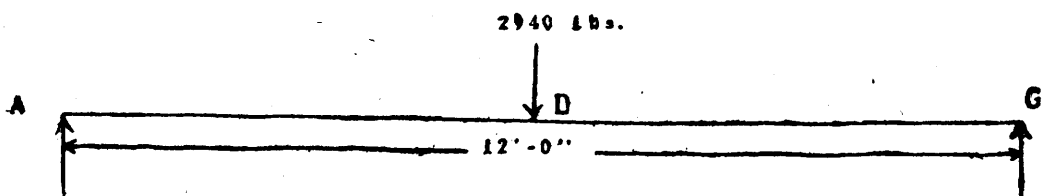


Fig. 52

(8) Therefore, deflection at centre due to load at B (Fig. 50) is :

$$\delta c_B = \frac{W_B \times a \times X}{E \times I \times (\ a + b\ )} \times \frac{b^2 - 2\, ab - X^2}{6}$$

where $a = 1$; $b = 11$; $X = 6$; $W_B = 8079$ lb.

Substituting the values we have

$$\delta c_B = \frac{8079 \times 1 \times 6}{E \times I \times (\ 1 + 11\ )} \times \frac{121 - 22 - 36}{6}$$

Now $E = 2 \times 10^6 \times 12 \times 12$ lb. per sq. ft.

$$\text{and } I = \frac{bd^3}{12} = \frac{14 \times 13^3}{12} \times \frac{1}{12^4} \text{ ft.}^4$$

$$= \frac{14 \times 13^3}{12^5}$$

$$\therefore \delta c_B = \frac{8079 \times 107}{12 \times E \times I} = \cdot 00201 \text{ feet.}$$

(9) Again deflection at centre of twin-transom due to load at C (Fig. 51) is

$$\delta c_C = \frac{W_C \times a \times X}{E \times I \times (a + b)} \times \frac{b^2 - 2\,ab - X^2}{6}$$

where a = 3 ·75 ; b = 8 ·25 ; X = 6 ; W_C = 11661 lb.

$$\therefore \delta c_C = \frac{11661 \times 3 \cdot 75 \times 6}{E \times I \times (3 \cdot 75 + 8 \cdot 25)} \times \frac{8 \cdot 25^2 - 2 \times 3 \cdot 75 \times 8 \cdot 25^2 - 6^2}{6}$$

$$= \frac{11661 \times 3 \cdot 75 \times 94}{12 \times E \times I} = 0 \cdot 0096.$$

(10) Hence total deflection at centre due to loads at B, C, E and F is
$2\,(\delta c_B + \delta c_C) = 2\,(\cdot 0020 + 0096) = \cdot 0232$ feet.

(11) Again deflection at centre 'D' due to load at D (Fig. 52) is

$$\delta c_D = \frac{5}{384} \times \frac{W_D \times 12^3}{(2 \times 10^6 \times 12 \times 12) \times \frac{14 \times 13^3}{12^5}}$$

$= \cdot 0018 = \cdot 002$ feet (say).

(12) $\therefore$ Total deflection at centre 'D' of the twin-transom due to (10) and (11) is $\delta_C = \cdot 0232 + \cdot 002 = \cdot 0252$ feet.

(13) Now allowable deflection is $\frac{1}{240}$th of the span, i.e., allowable

$$\delta_C = \frac{1}{240} \times \frac{12}{1} = 0 \cdot 05 \text{ feet.}$$

(14) $\therefore$ Actual $\delta_C <$ allowable δ_C

$\therefore$ Section of twin-transom is safe against deflection.

Design of King Truss :—

If the total load (dead and live) on each of the two trusses be considered as 'W', then the distribution of load on the node points and the type of forces (stresses) and their magnitude developed in various members of each truss are as shown in Fig. 53 from the simple theory of resolution of forces.

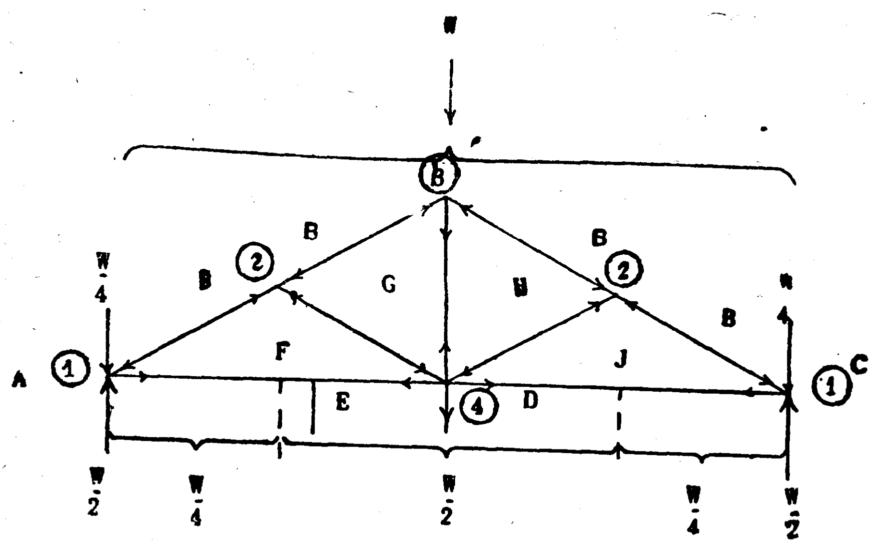
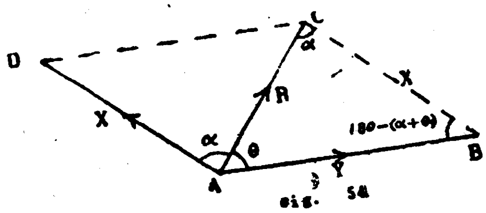


Fig 53

Mathematical computation of stresses in members of the truss is based on the simple theory of resolution of forces. According to this a force 'R' acting in a particular direction may be resolved into two component forces acting in any desired direction provided the angles between the direction of 'R' and that of the resolved forces are known (see Fig. 54).



By parallelogram of forces (or by Lame's theorem) we have

$$\left.\begin{aligned} X &= \frac{R \sin\theta}{\operatorname{Sin}(\alpha+\theta)} \\ \text{and } y &= \frac{R\sin\alpha}{\operatorname{Sin}(\theta+\alpha)} \end{aligned}\right\}$$

because in ABC, (Fig. 54)

$$\frac{x}{\operatorname{Sin}\theta} = \frac{y}{\operatorname{Sin}\alpha} = \frac{R}{\operatorname{Sin}[180-(\alpha+\theta)]}$$

$$\text{Or } \frac{X}{\operatorname{Sin}\theta} = \frac{Y}{\operatorname{Sin}\alpha} = \frac{R}{\operatorname{Sin}(\alpha+\theta)}$$

Or directly from Lame's theorem, without **drawing the** parallelogram, we get

$$\frac{x}{\operatorname{Sin}\theta} = \frac{y}{\operatorname{Sin}\alpha} = \frac{R}{\operatorname{Sin}(\alpha+\theta)}$$

Total load 'W' on one truss is transmitted to each of the panel joints 1, 4 and 1 through ends of transoms in the ratio of

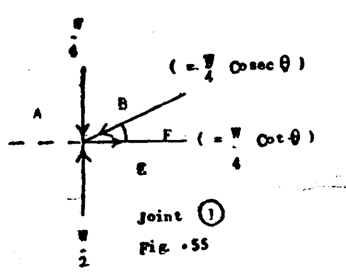
$\frac{W}{2}$ at joint 4

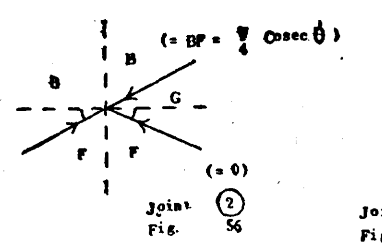
$\frac{W}{4}$ at joint 1

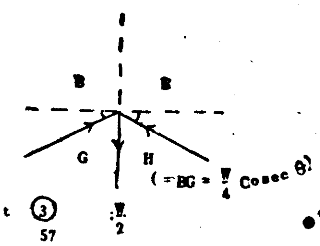
$\frac{W}{4}$ at joint 1

Now at each joint or panel point or node, resolving horizontal and vertical forces in equilibrium we get at joints 1 :—

$$\left.\begin{aligned} \frac{W}{2} - \frac{W}{4} - BF\sin\theta &= 0 \ldots\ldots\ldots\ldots\ldots\ldots (1_a) \\ \text{Also } BF\cos\theta - FE &= 0 \ldots\ldots\ldots\ldots\ldots\ldots (1_b) \end{aligned}\right\} \text{Fig. 55.}$$







$\therefore$ From (1_a) we get force in BF $= \frac{W}{4}$ cosec θ.............(compression)

and from (1_b) we get force in FE $= \frac{W}{4}$ cot θ......................(tension)

Where θ is the angle tie beam makes with the principal rafter.

At joints (2) :—

$$\left.\begin{array}{l} BF \sin\theta - BG \sin\theta + FG \sin\theta = 0 \\ \therefore (BF - BG + FG) = 0 \ldots\ldots (2_a) \\ \text{Also } BF \cos\theta - BG \cos\theta - FG \cos\theta = 0 \\ \therefore (BF - BG - FG) = 0 \ldots\ldots (2_b) \end{array}\right\} \text{Fig. 55.}$$

$\therefore$ From (2_a) we get forces in BF $=$ BG.................(compression)

and $\therefore$ from (2_b) we get froces in FG $= 0$....................(redundent).

At joint (3) :—

$BG \sin\theta + HB \sin\theta - GH = 0$...........................(3_a)

and $BG \cos\theta - HB \cos\theta \quad = 0$...........................(3_b)

$\therefore$ From (3_a) we get $2\ BG \sin\theta = GH$

and from (3_b) we get $BG = HB$

Now from (3_a) we have

$2\ BG = GH$

i.e., $2\ BF \sin\theta = GH$

i.e., $2 \times \frac{W}{4} \text{cosec}\,\theta \sin\theta = GH$

$\therefore DE = \frac{W}{2}$ ....(tension)

Let us now find the total 'W' coming on each truss.

$W = W_D + W_L$ where $W_D =$ Dead load.

$W_L =$ Live load due to 10-ton road roller.

W_D on each truss is :

(1) Due to dead load of structure

i.e., due to

Half deck area + two roadbearers + dead load of one of the twin-transoms

i.e. $\left(30 \times 5 \times \frac{4 \cdot 25}{12} \times 60\right) + 2\left(\frac{13}{12} \times \frac{6}{12} \times \frac{30}{1} \times \frac{60}{1}\right) + \left(\frac{13}{12} \times \frac{7}{12} \times \frac{14}{1} \times \frac{60}{1}\right)$

i.e. 3188 + 1950 + 530.

i.e. 5668 lb.

(2) Due to U.D.D.L. of 0·34 ton per linear foot of each traffic lane is $\frac{1}{2}$ (0·34 × 2240 × 30), i.e., 11424 lb.

(3) Due to dead weight of truss itself (assuming a load of $\frac{1}{2}$ ton per truss) is 112 0lb.

(4) $\therefore W_D = 5668 + 11424 + 1120 = 18200$ lb.

Max. W_L coming on one truss due to 10-ton road roller is at panel point (4) of the truss and is equal to $6 \cdot 67 \times 2240 = 14933$ lb. (approximate method).

It will be interesting to know how this 6·67 tons of live load out of a total of 10-ton road roller, come on the joint (4) through the central twin-transom.

The full load of a 10-ton road roller is divided between two trusses in the ratio as shown (Fig. 58*a*) below taking the extreme limit when one rear side wheel of the roller just scrapes or touches the wheel guard.

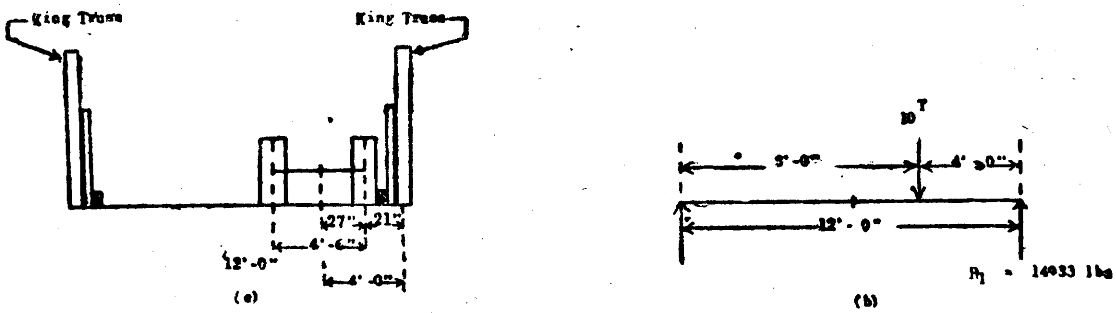


Fig. 58

The approximate standard dimension of a 10-ton road roller is as shown in Fig. 59.

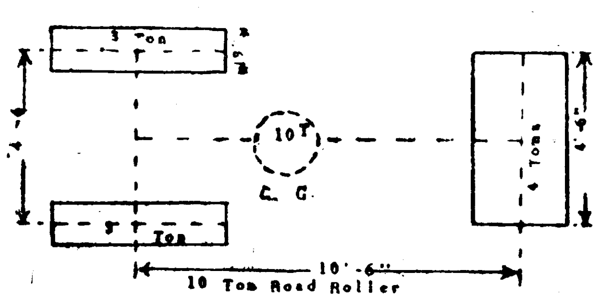


Fig. 59

From Figs. 58*a* and 58*b* it is evident that in the extreme case the King rods of the truss will take load R_1 where

$$R_1 \times 12 = \text{Moving load} \times 8 \text{ feet}$$

$$\therefore R_1 \times 12 = (10 \times 2240) \times 8 \text{ feet}$$

$$\therefore R_1 = W_L = \frac{10 \times 2240 \times 8}{12}$$

$$R_1 = 6 \cdot 67 \text{ tons} = 14933 \text{ lb.}$$

(5) $\therefore W_L = 14933$ lb.

(6) $\therefore W = W_D + W_L = (18202 + 14933)$ lb.

Design of King rod GH :—

(1) Load on King rod $= \dfrac{W_D}{2} + W_L$ (Figs. 53 and 58*b*)

$$= \frac{18200}{2} + 14933$$

$$= 9100 + 14933 = 24033 \text{ lb.}$$

Note.—Dead weight W_D is distributed as per Fig. 53. Max. live load on King rod is when centre of gravity of road roller is on the twin-transom at the same time one of the rear wheels just scrapes the wheel guard. Fig. 58*a*.

(2) We will use two steel rods as member GH.

(3) $\therefore$ Weight on each steel rod $= \frac{24033}{2}$

$= 12017$ lb.

(4) Sectional area of each rod $= \frac{\text{load on each rod}}{\text{safe stress of steel}}$

$$\therefore a = \frac{12017}{16000} = 0 \cdot 75 \text{ sq. in.}$$

$$\therefore d^2 = \frac{\cdot 75 \times 4}{3 \cdot 1416} = 0 \cdot 9$$

$$\therefore d = 0 \cdot 91 \text{ inch.}$$

(5) Use two 1″ ϕ rods as twin King rod.

Design of principal rafter BF, BG, HB and BJ :—

(1) BF = BG = HB = BJ.

(2) Let θ = 30° so that length of each BF, BG, HB and BJ is = 8·5 feet.

(3) Now cosec θ = cosec 30° = 2

and Cot θ = Cot 30° = 1·155

$$\text{Again BF} = \frac{W}{4} \operatorname{cosec} \theta \text{ ....(compression)}$$

$$= \left(\frac{W_D}{4} + W_L \right) \operatorname{Cosec} \theta$$

$$= \left(\frac{18200}{4} + 14933 \right) \times 2$$

$$= 38966 \text{ lb. (compression).}$$

(4) As the member is in compression design it as a column.

$$\text{Now slenderness ratio} = \frac{l}{d} = \frac{8 \cdot 5 \times 12}{5} = 20$$

$\therefore$ Design it as a long column

$$\text{Permissible value of compressive stress } f_p = f_c \left(1 - \frac{l}{60d} \right)$$

$$= 1700 \left(1 - \frac{8 \cdot 5 \times 12}{60 \times 5} \right)$$

$$= 1200 \text{ (appr.)}$$

$$\text{Now a} = \frac{38966}{1200} = 32 \cdot 5 \text{ sq. in.}$$

(5) Use an overall section of 9″ × 5″ which gives an overall area = 45 sq. in., which allows for reduction of joints, etc., which then gives a net section of 33 sq. in.

Note.—(1) Within slenderness ratio of $\frac{l}{d} = 15$, a column is considered short and f_c for short column of timber sal = 1700 lb./sq. in. A short column fails by pure compression.

(2) Slenderness ratio between 15 and 45 a column is considered as a long column and will fail more due to buckling than pure compression.

Permissible value of compressive stress f_p for long column is some fraction of the allowable compression f_c parallel to grain of a short column. The relation being $f_p = f_c \left(1 - \frac{l}{60d} \right)$ ....by A.R.E.A.

(3) For a slenderness ratio $>$ 45, either

$$\left.\begin{array}{l}(a)\ \text{column section changed} \\ \qquad\text{or} \\ (b)\ \text{length of column reduced} \\ \qquad\text{by bracing}\end{array}\right\}\ \text{such that}$$

$\frac{l}{d}$ comes within 45 and then the column is designed as per long column formula.

Design of tie beam FE and JD :—

(1) From (1*b*), FE is in tension and $= \frac{W}{4} \cot \theta$.

$$\therefore \text{FE} = \text{JD} = \frac{W}{4} \cot \theta$$

$$\therefore \text{FE} = \text{JD} = \left(\frac{W_D}{4} + W_L\right) \cot \theta$$

$$= 19483 \times 1 \cdot 155$$

$$= 22503 \text{ lb. (tension).}$$

(2) As the member is in pure tension, section of member

$$= \frac{\text{Total load on member}}{\text{Safe tensile stress of sal}}$$

$$\therefore a = \frac{22503}{2400} = 9 \cdot 4 \text{ sq. in. net area.}$$

Allowing $\frac{1}{3}$ extra area for joinery, bolts and fastenings, etc., we have

$$a = 9 \cdot 4 + \frac{9 \cdot 4}{3} = 12 \cdot 5 \text{ sq. inches overall area.}$$

(3) Use a tie beam of sectional area 5″ × 4″ which is ample and practicable when considered in conjunction with the member of the principal rafter which is 6″ × 5″.

Design of struts FG and HJ :—

(1) They carry no load as was seen by the equation in (2*b*). But they help in bracing the long length of principal rafter which are then designed as short columns. Without using the struts FG and HJ, the principal rafter BF, BG, HB and BJ would give slanderness ratio beyond 15 and thus would have to be designed as long columns otherwise.

(2) Use ∴ a section of 3″ × 3″ as member FG and HJ.

TABLE I

Timber required is as follows

A complete statement in tabular form of a Bridge 20 feet span, 10 feet traffic width, made of sal *timber of standard structural grade No. 2*

Serial No.	Name of Items	Section b × d	Sectional area per piece	Length per piece	Cu. ft. per piece	Number of pieces required	Total Cu. ft.	Cons-tructional remarks	Serial No.
		in. × in.	sq. in.	ft. in.	Cu. ft.	Nos.	Cu. ft.		
1	Decking of sleepers								
	Main Deck ..	12×2·75	33	12 0	2·75	30	82·50	1*a*, Fig. 7 of Pt. I and Fig. 36 of Pt. III	1
	Wearing Deck ..	12×1·5	18	10 0	1·25	30	37·50		
2	Roadbearers ..	6×13	78	16 0	8·60	8	68·80	2*a*, and Figs. 63 and 64	2
3	Bridge seat ..	6×3	18	13 0	1·60	2	3·20	3*a* and Figs. 40*a* and 40*b*, Pt. III	3
4	Solid strutting or spacers ..	4×6	24	4 0	0·60	4	2·10	4*a* and Fig. 6, Pt. I	4
				2 3	0·38	8	4·20		
5	Transoms ..	7×13	91	22 0	15·00	2	30·00	5*a*, Fig. 47	5
6	King rod Truss								
	Principal rafer ..	5×9	45	9 0	2·81	8	22·48	6*a*, Fig. 61	6
	Tie Beam ..	5×4	20	16 0	2·22	4	8·88	6*b*	
	Struts ..	3×3	9	9 0	0·55	4	2·20	6*c*	
	King rods ..	Steel rod 1″ ϕ	..	..	..	4	..	6*d*, Fig. 62	
7	Guard Blocks ..	5×3	15	0 6	0·05	16	0·80	7*a*	7
8	Wheel guards or Rib-bonds ..	5×4	20	16 0	2·22	4	8·88	8*a*	8
9	Rail posts ..	5×4	20	4 0	0·55	14	7·70	9*a*	9
10	Hand Rails ..	3×4	12	16 6	1·38	8	11·04	10*a*	10
11	Inclined strut of Bracing King Truss ..	5×5	25	10 0	1·71	2	3·42	11*a*, Figs. 60 and 62	11
12	Inclined tie for Wind Bracing King Truss	½″ ϕ rod	..	..	..	4	..	11*b*, Fig. 60	12

Total cu. ft. of timber required 303·70.

NOTE ON CONSTRUCTIONAL REMARKS—TABLE I

(1*a*) Same as that for Remarks (1*b*) Table I in Part I and Fig. 36.

(2*a*) Same as that for Remarks (2*a*) and (2*b*) Table I in Part I and also as in 2*a* Table I, Part II and Figs. 63 and 64.

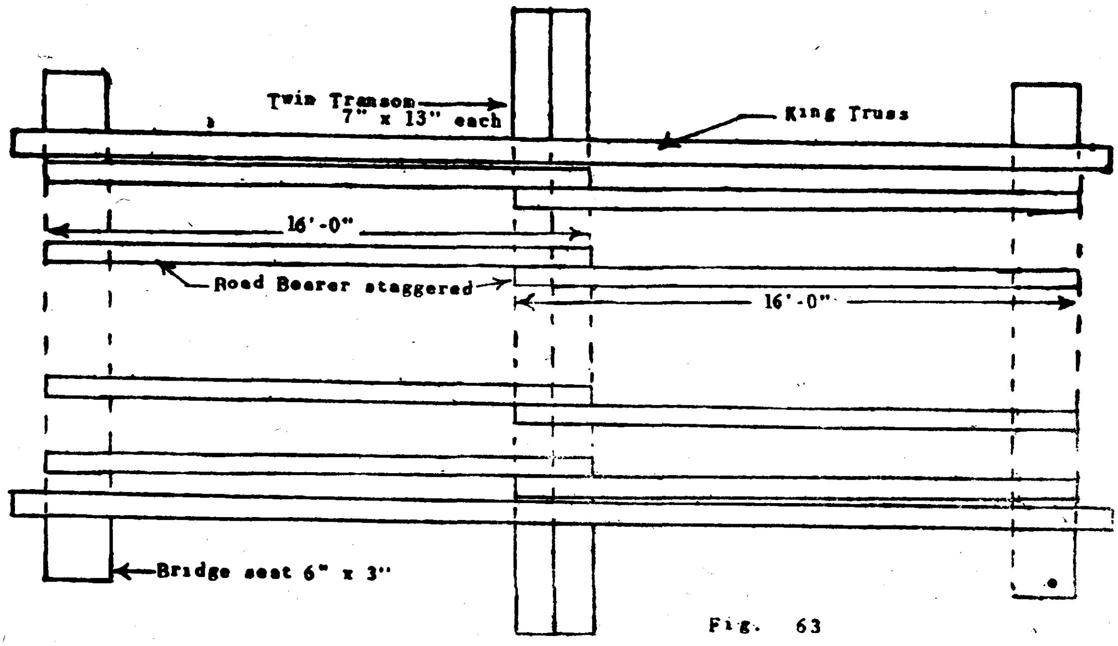
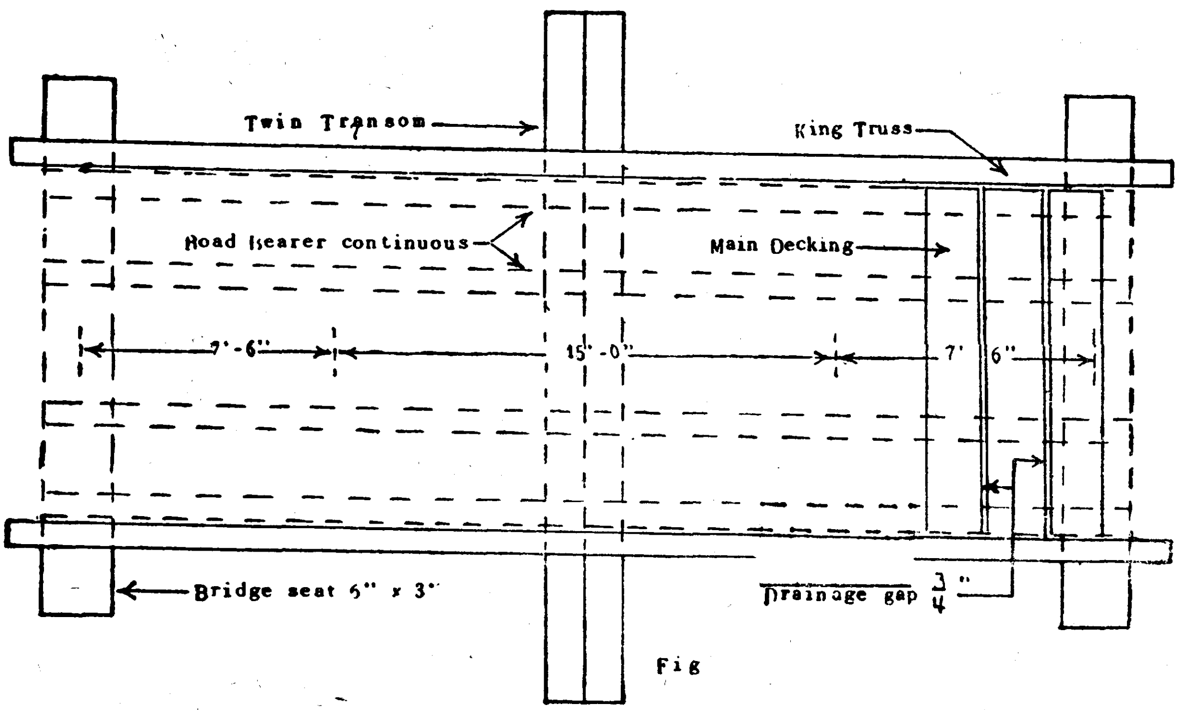


Fig. 63



Fig

(3*a*) Same as that for Remarks 2*a* Table I, Part I and also as in Figs. 40*a* and 40*b* of Part III.

(4*a*) Same as that for Remarks 2*b* Table I, Part I and Fig. 6.

(5a) Each separate transom of 7″ × 13″ connected at their common abutting face at the position of neutral axis by hardwood tree nails or steel dowel pins such that they act as a twin-transom Fig. 47.

(6a) Principal rafter to be in one piece if possible ; failing this proper lengthening joint to be given. Foot of principal rafters to have bridle joints in additon to steel strap (Fig. 61).

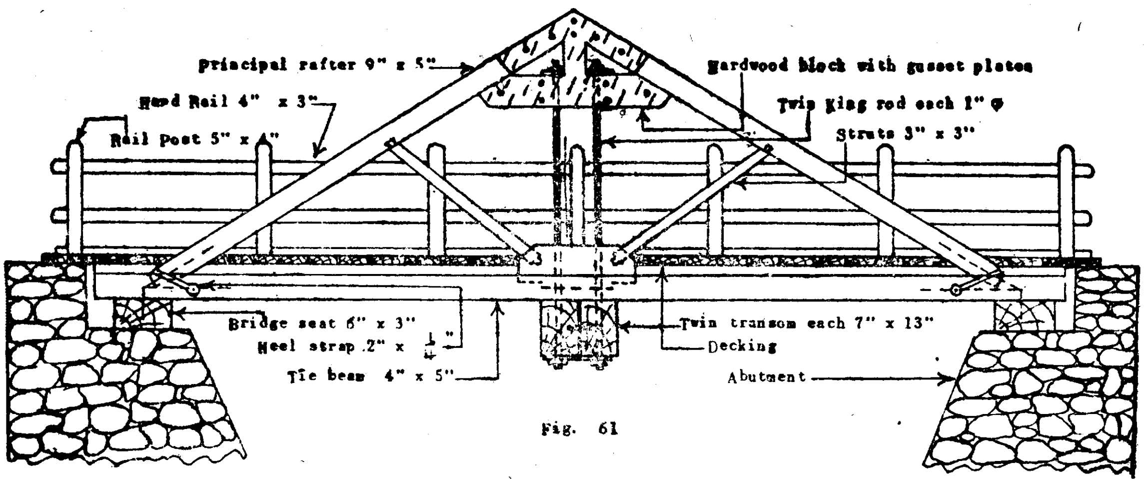


Fig. 61

(6b) Tie beam to be in one piece if available ; failing this proper lengthening joint to be given. Ends of tie beams jointed to feet of principal rafters by bridle joints in addition to steel strap (Fig. 61).

(6c) As shown in Fig. 61.

(6d) To be jointed properly as in Figs. 62a and 62b ; note that hardwood block shown at 'a' in Fig. 62 is sandwitched between two steel plates and bolted neck of this block to be 6″ wide as shown.

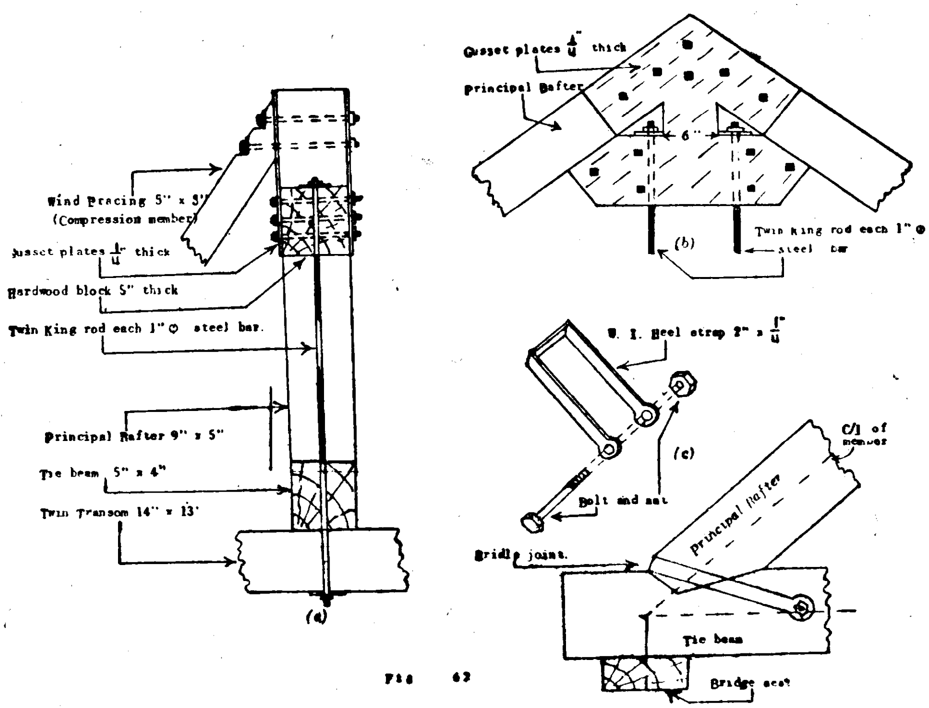


Fig 62

The whole truss to be properly jointed and erected.

Timber trusses should have a much higher ratio of depth to span. For triangular roof trusses as in the case of our King truss bridge a ratio of depth to span of about $\frac{1}{4}$ is recommended.

Timber trusses should be provided with camber. A camber at mid-span of $\frac{1}{240}$th of the span has been found to give satisfactory results. In important structures like bridges, the deflection should be calculated and

(1) an initial camber which is greater than the calculated deflection after several years should be provided. Heavy timber structures also sag due to slip in the joints. In the case of our bolted joint structures (as opposed to split-ring and disc dowel jointed structures) additional allowance should be given for

(2) an initial slip of $\frac{1}{8}''$ (due to oversize allowed in the bolt hole) over and above

(3) an approximate slip of 0·05 inch at full load.

It may be noted that bolted joints are much less stiff than joints in which connectors, disc dowels, etc., are used and thus camber allowed in a bolted joint structure is more.

Central lines of members of truss at bridge seat ends to meet in a point as shown in Figs. 41 and 61.

(7*a*), (8*a*), (9*a*), (10*a*) As per Figs. 6, 7 and 10, Part I.

(11*a*) As in Figs. 60 and 62*a* to take up compression due to wind force.

(11*b*) As in Fig. 60.

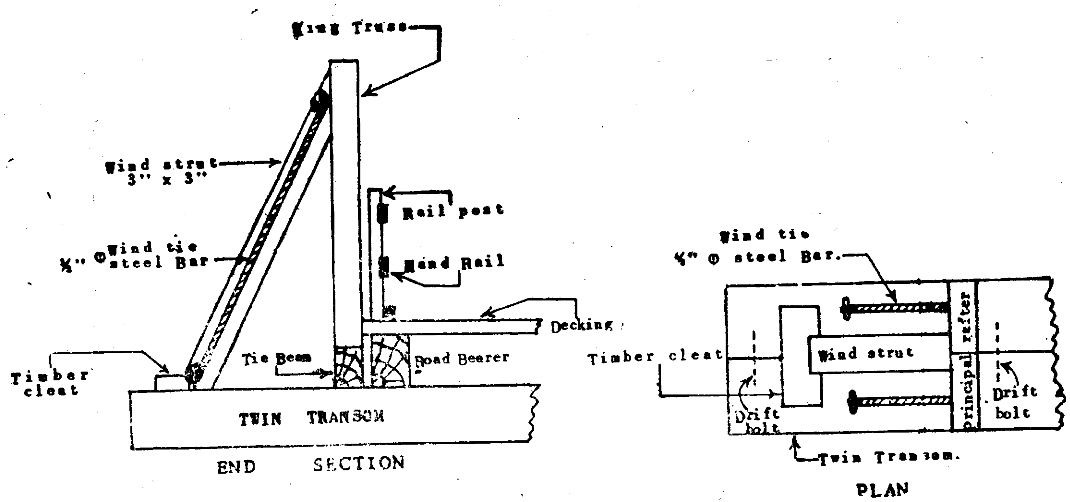


Fig. 60.

TABLE II

Hardware required for 30 feet Span Bridge

Serial No.	To connect	Bolts and Nuts			Iron Washers*			Nails 3" long $\frac{3}{8}$" dia.	Spikes 6" long $\frac{1}{4}$" dia.	Constructional remarks	General remarks	Serial No.
		Dia.	Length	No. required	Thickness	Dia.	No. required					
		inch	inch	Nos.	inch	inch	Nos.					
1	$1\frac{1}{2}$" wearing planks with main decking.	..	..	..	..	..	..	300	..	1a, Fig. 36, Pt. III		1
2	Main Decking to Roadbearers.	..	..	..	..	..	..	..	240	2a		2
3	Roadbearers to Bridge seat.	$\frac{3}{4}$ Drift bolt	10	8	..	..	..	..	..	3a, Figs. 6 and 8, Pt. I	Use $\frac{3}{4}$" ϕ drift bolts instead of ordinary Bolt and Nut.	3
4	Roadbearers to Transoms	$\frac{3}{4}$ or $\frac{3}{4}$	10 ..	8 ..	.. ..	.. ..	.. ..	.. ..	.. ..	4a, Fig. 63 4b, Fig. 40	Use wooden cleats and drift bolts.	4
5	Twin-transom to Tie beam	1" ϕ steel rod	10 feet	4	..	..	..	..	..	5a, Figs. 61 and 62	Steel rod threaded at both ends to take bolts. Steel flats $\frac{1}{4}$" thick to be used between timber and bolts.	5
6	Guards blocks and Wheel guard to main decking.	$\frac{3}{4}$	12	20	$\frac{1}{2}$	2	40	..	..	6a, Fig. 10		6
7	Rail post to main decking	..	..	..	..	..	..	..	..	7a, Fig. 7		7
8	Hand rail to Rail post	$\frac{1}{2}$	9	28	$\frac{1}{4}$	2	56	..	..	8a, Fig. 6		8
9	Tie beam to Principal rafter.	$\frac{3}{4}$	7	4	..	..	..	..	..	9a, Fig. 62c	Use 'U' shaped W.I. heel strap 2" wide and $\frac{1}{4}$" thick.	9
10	Principal rafter to King rods.	$\frac{1}{2}$	7	12	..	..	..	..	..	10a, Fig. 62	Two flat W.I. steel plate $\frac{1}{4}$" thick and of shape as shown in 62b covering the hard block on both faces and bolted together.	10
11	Struts to Principal rafter	$\frac{1}{4}$	7	24	..	..	..	..	..	11a	Use 'T' type W.I. strap $\frac{1}{4}$" thick and $\frac{1}{2}$" wide.	11
12	Struts to King rods	..	..	..	..	..	..	..	..	12a, Fig. 61	Use Hardwood block and carpentry joint.	12
13	Inclined steel rod to King truss.	$\frac{1}{2}$" ϕ steel rod	10 feet	4	..	..	..	..	..	13a, Fig. 60	Use eye hook bolts $\frac{1}{2}$" ϕ as shown in Fig.	13

NOTE ON CONSTRUCTIONAL REMARKS—TABLE II

(1*a*) Same as that in Remarks 1*a*, Table II, Part I and Fig. 36, Part III.

(2*a*) Same as that in Remarks 2*a*, Table II, Part I.

(3*a*) Same as that in Remarks 3*a*, Table II, Part I and Figs. 6 and 8, Part I.

(4*a*) When each roadbearer is of length 16′ 0″ as in Fig. 63.

(4*b*) When each roadbearer is in one piece of 32′ 0″ length (Fig. 64). In both cases, end roadbearers cleated to twin-transom by drift bolts and intermediate roadbearers kept in position by spacers or solid strutting as in Fig. 6, Part I.

(5*a*) As in Figs. 61 and 62.

(6*a*) As in Fig. 10, Part I.

(7*a*) Same as that in Remarks 5*a*, Table II, Part I and Fig. 7, Part I.

(8*a*) Same as that in Remarks 6*a*, Table II, Part I and Fig. 6, Part I.

(9*a*) As in Fig. 62*c*.

(10*a*) As in Figs. 62*c* and 62*b*.

(11*a*) Head of each strut has an oblique tenon which is housed into the principal rafter to form a vertical abutment.

In addition use 'T' type W.I. strap with bolts and nuts when principal rafter is in two pieces.

(12*a*) Foot of each strut is connected to King rods through a hardwood block by a single abutment tenon joint Fig. 61.

(13) As in Fig. 60. It takes up tension due to wind force and thus keep the trusses vertical.

(*Continued*)

ON THE USE OF THE SIMPLIFIED PLANIMETER

BY DR. K. KADAMBI

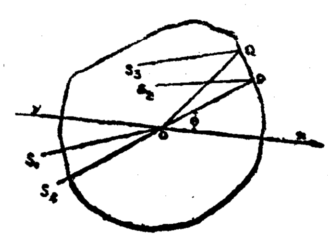
(*Assistant Silviculturist, Forest Research Institute, Dehra Dun*)

Very recently the Honorary Editor of the *Indian Forester* (Mr. M. S. Raghavan) was kind enough to bring to my notice an article published in the November 1932 issue of this Journal, entitled " A Simple Method of Measuring Small Areas ", in which the usefulness of a pocket pen-knife for planimetering small areas on maps, charts, etc., has been demonstrated. According to the author L. N. Seaman, who quotes Professor Robert Sparks of the Dunham Laboratory of Electrical Engineering, Yale University, in this connection, the application of the pen-knife for planimetering purposes is limited by "(*a*) the size of the figure to be measured, (*b*) the accuracy and graduation of the measuring scale, and (*c*) the skill of the operator". I have made it clear, in my article of the May issue that the simplified planimeter, as now constructed, was discovered by accident through a Forest Ranger student and how the first idea in this connection emanated also from a double-bladed pocket pen-knife. But, the instrument described by me namely, the bent rod with a tracing point at one end and a crescent shaped convex knife-edge at the other, is a vast improvement on the pen-knife, and the limitations imposed on the usefulness of the pen-knife planimeter as regards the size of the figure which can be measured and the skill of the operator are eliminated in this instrument to a large extent. The simplified planimeter could be made up to 12" or more long, and the distance between the tracing point and the knife-edge could be correctly fixed by the manufacturer. Very little skill is required for its operation, and one soon becomes an expert. In fact I have sometimes found that less mistakes are apt to be made by the beginner with this instrument than with a Polar type planimeter. A foot rule graduated to say 1/50th of an inch gives readings accurate enough for the purpose. The planimeter is probably as accurate as the graduations of the best scales will permit of reading.

Small mistakes made in the location of the centre of a figure do not appreciably diminish the accuracy of the instrument. Even with the polar type planimeter slight errors are apt to occur, and one is usually recommended to take the average of three readings. As stated by Seaman in connection with the pen-knife or "Hatchet Planimeter" as it has been called by Sparks", with little practice it is possible to measure areas in this way with as much accuracy and with very little more trouble than with most commercial planimeters". If this be true of a pocket pen-knife planimeter, it is obvious that much more accurate and comfortable work could be turned out with the simplified planimeter, as several of my forest surveyors, draughtsmen, rangers and I have actually done for a long number of years during our executive careers.

The mathematical proof of this method of planimetry has been detailed by Robert Sparks which I have reproduced below in more or less his own words :—

Let O be the point from which the tracing point is to be started (see figure). Let S_1 be the first position of the knife-edge and S_4 the last. Suppose the planimeter is moved from the first position to a point P on the curve along a straight line making an angle θ with the axis. Then let it be moved a slight amount along the curve to a point Q. The planimeter will take up positions as shown in the figure.



(after sparks.)

We let

$$XOP = \theta,$$
$$XOQ = \theta + d\,\theta,$$
$$OPQ = \psi,$$
$$YOS_1 = \phi$$

inclination S_2P to OX $= \phi'$,

,, S_3Q to OX $= \phi + d\,\phi'$,

,, S_4O to OX $= \phi + d\,\phi$.

Then we have, making use of the curve of pursuit,

$$\tan \frac{\theta-\phi'}{2} = e - (r/c) \tan \frac{\theta-\phi}{2} \qquad (1)$$

and $$\tan \frac{\theta + d\theta - \phi' - d\phi'}{2} = e - (r + dr)\ 1/c \tan \frac{\theta + d\theta - \phi - d\phi}{2}.$$

Differentiating this expression

$$\frac{d\theta - d\phi'}{\sin(\theta - \phi')} = \frac{dr}{c} + \frac{d\theta - d\phi}{\sin(\theta - \phi)} \qquad (2)$$

Then the angle which the arc makes with the rod is $\psi - \theta + \phi'$ at P and it is, $\psi - \theta + \phi' + d\phi$ at Q.

therefore

$$\frac{d\phi'}{\sin(\psi - \theta + \phi')} = \frac{ds}{c},$$

or, what is the same thing,

$$cd\phi' = \{ \sin\psi \cos(\theta - \phi) - \cos\psi \sin(\theta - \phi) \} ds,$$

after further combining

$$cd\phi' = rd\theta \cos(\theta - \phi') - dr \sin(\theta - \phi') \qquad (3)$$

Then we put equation 3 in equation 2 and obtain

$$\frac{cd\theta - rd\theta \cos(\theta - \phi')}{(\theta - \phi')} - dr + \frac{c(d\theta - d\phi)}{\sin(\theta - \phi)}$$

making use of equation 1

$$\frac{d\theta - d\phi}{\sin(\theta - \phi)} = \frac{d\theta}{2}\left(I - \frac{r}{c}\right) e^{r/c} \cot \frac{\theta - \phi}{2} + \frac{d\theta}{2}\left(I + \frac{r}{c}\right) e^{(r/c)} \tan \frac{\theta - \phi}{2}$$

clearing fractions

$$d\theta - d\phi = \left[\left(I \frac{r}{c}\right) e^{r/c} \cos^2 \frac{\theta - \phi}{2} + \left(I + \frac{r}{c}\right) e^{-(r/c)} \sin^2 \frac{\theta - \phi}{2}\right] d\theta$$

and, making substitutions for the double angle,

$$d\theta - d\phi = \frac{1}{2}\left[\left(I - \frac{r}{c}\right) e^{r/c} + \left(I + \frac{r}{c}\right) e^{-(r/c)}\right] d\theta$$
$$- \frac{1}{2}\left[\left(I + \frac{r}{c}\right) e^{-(r/c)} - \left(I - \frac{r}{c}\right) e^{r/c}\right] d\theta \cos(\theta - \phi)$$

The two parts are each able to be expressed in series thus

$$d\theta - d\phi = \left(I - \frac{r^2}{2c^2} - \frac{r^4}{8c^4} - \frac{r^6}{144c^6} - - - \right) d\theta$$
$$- \left(\frac{r^3}{3c^3} + \frac{r^5}{30c^5} + + + \right) \cos(\theta - \phi)\, d\theta.$$

Integrating termwise

$$c^2\Phi = A + \frac{I}{8c^2}\int_0^{2\pi} r^4 d\theta + \frac{1}{144c^4}\int_0^{2\pi} r^6 d\theta + + +$$
$$+ \int_0^{2\pi} \left(\frac{r^3}{3c} + \frac{r^5}{30c^3} + + + \right) \cos(\theta - \phi)\, d\theta.$$

This last expression is the required result. We notice that the left hand side of the equation is the square of the length of the planimeter multiplied by the angle it moved through in tracing the figure. If the angle is small as it will be when *r* is one quarter or less, then the chord is nearly equal to the arc and the length of the planimeter can be multiplied by the distance from the first position and the last position of the planimeter's knife-edge.

(The mathematical portion has been taken from : Journal of the Franklin Institute, June 1932).

NEW OR NOTEWORTHY PLANTS FROM THE UPPER GANGETIC PLAIN

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(*Continued from* Indian Forest Records (*New Series*) *Botany Vol. I, No. 5, 1939 pp. 223–236*)

SUMMARY

A number of new or noteworthy plants from the Upper Gangetic Plain are described. This part, together with the three already published, forms a useful supplement to Duthie's Flora of the Upper Gangetic Plain. For the benefit of those who may use this list, detailed descriptions are given of those plants which are not found in Hooker's Flora of British India.

The flora of this area is now practically completely known and any additions in future will probably be due to introduced species becoming naturalized rather than to indigenous species having been overlooked.

Attention is drawn to the amazing extent that some plants indigenous to Tropical America are becoming established and naturalized in the region of the Upper Gangetic Plain.

Introduction.—This paper is the fourth dealing with the author's studies of the flora of Upper Gangetic Plain*. Most of the material on which the present paper is based has been collected within recent years and is deposited in the Dehra Dun Herbarium.

The woody flora of this area is now practically completely known but it is probable that some species, especially of herbaceous and weedy plants, still remain to be collected and that future intensive and careful botanizing in the region may add a few more to the present list.

As in previous parts the sequence of families and genera is that adopted by Sir J. D. Hooker in the Flora of British India and with few exceptions the families are enumerated without change in nomenclature or terminology. The generic and specific names have, however, been amended in the light of the latest international rules of botanical nomenclature but where changes have occurred the synonym as it appears in Hooker's Flora of British India is given. For the benefit of Indian workers detailed descriptions of those plants which do not find a place in Hooker's book and of which it may, therefore, be difficult or inconvenient to find descriptions are also given.

In the following pages 35 species belonging to 32 genera and 20 families are enumerated, all found within the limits of the area of the Upper Gangetic Plain, but which were till now not reported from this region.

This supplement to the 'Flora of the Upper Gangetic Plain, and of the adjacent Siwalik and Sub-Himalayan tracts' which contains a total of about 170 newly recorded plants has been compiled so as to place on record all the plants discovered in the area since the publication of the original work by Duthie so that this knowledge may not be lost and may prove handy at the time of revision of the flora.

It is worthwhile mentioning here that while checking up specimens in the Dehra Dun Herbarium I have noticed that a number of species have been wrongly assigned by Duthie as occurring in our area as a result of erroneous identification or because the locality mentioned is wrong. To cite only a few examples, Duthie on p. 233 mentions that *Pueraria wallichii* DC. was collected by Wallich from Hardwar. I have, however, seen no specimens from our area and conclude that Wallich's specimen was wrongly localized. Similarly I have seen no specimens of *Mucuna atropurpurea* DC. from our area although Duthie reports on p. 236 that it occurs in Dehra Dun and Siwalik range. Possibly it has been confused with *M. imbricata* DC. Such examples could be multiplied but I propose to deal this subject in a subsequent communication.

* Recently introduced or otherwise imperfectly known plants from the Upper Gangetic Plain Pt. I, Journ. Ind. Bot. Soc. XIV, 4 (1935) pp. 339–348. Pt. II l.c. XV, 2 (1936) pp. 149–167, Pt. III, Ind. For. Rec. (n.s.) Botany 1, 5 (1939) pp. 22[illegible]235.

MAGNOLIACEÆ

Michelia champaca Linn. ; Fl. Br. Ind. 1, p. 42.

'Bhalaon, 2,000 ft., Ramnagar div., 1, 2, 1922, A. E. Osmaston 1187 ! A tree'.

This tall handsome evergreen tree is commonly planted round villages and near temples throughout the area. At Bhalaon near Ramnagar, however, it is found growing in ravines in 'Sal' forest and is either truly indigenous or has run wild and become naturalized.

GERANIACEÆ

Oxalis pes-capræ Linn., Sp. Pl. 434 (1753) ; Calder in Rec. Bot. Surv. Ind. VI (1919) 329 t. 4 ; Fyson in Fl. South Ind. Hill Stations 1 (1932) 75 t. 52.

'Meerut, 10–3–49, Yagya Dutt Tiagi, Dehra Dun Herb. No. 105385 ! Naturalized in shady places'.

A herb with a bulbous root-stock, about 6–12 inches high. Leaves arising directly from the bulbous root-stock ; petiole slender, erect, usually 2·5–6 inches long, rarely up to 8 inches. Leaves trifoliolate, with obscurely pulvinate sessile leaflets. Leaflets two-lobed, obcordate, cuneate at the base, ·3 inch long, ·5 inch broad at the broadest part, membranous, glabrous above, somewhat villous beneath, spotted with black dots which turn brown on drying ; Secondary nerves 3–4 pairs, divergent from the base of the midrib, straight. Scapes elongate, much longer than the petioles, usually 8–10 inches long, rarely more, glabrous. Umbels few–or many–flowered, minutely bracteate ; bracts few minute, involucrate, hairy, persistent ; pedicels unequal, ·4–·8 inch long, cernuous when young, erect at the time of flowering, pilose. Flowers about 1·2 inches long, about ·88 inch across. Sepals 5, lanceolate, ·2 inch long, ·05 inch broad, much shorter than the petals, acute, membranous, with two contiguous glands towards the apex. Petals 5, golden-yellow, united a little above the base only, shortly clawed, oblong-cuneate at the base, ·5 inch long, ·08 inch broad, glabrous. Stamens 10, alternately longer and shorter, united into a tube for a considerable way, free above ; longer filaments about ·3 inch long, shorter flaments ·2 inch long ; anthers oblong. Ovary ovate, ·2 inch long. Styles 5, very short, hairy ; stigmas 5, capitellate.

A native of the Cape of Good Hope and of recent introduction in this country. It has already become completely naturalized in Lahore and on the Nilgiris and Pulney Hills.

LEGUMINOSÆ

Crotalaria saltiana Andr. Bot. Rep. (1811) t. 648 ; Prain ex-King in Journ. AS. Soc. Beng. 66² (1897) 41, 353, *C. Striata* DC. ; HK. f. Fl. Br. Ind. 2, p. 84 (excluding the synonyms *C. Brownei* Bertero and *C. latifolia* Roxb.).

'Dehra Dun, December 1938, M. B. Raizada, Dehra Dun Herb. No. 78313 ! Not cultivated but apparently as an escape'.

This species is now seen running wild and deserves a place in the flora as much as an indigenous species.

ROSACEÆ

Rosa moschata Hermann ; Fl. Br. Ind. ii, p. 367.

'Near Chandbagh, Dehra Dun, May 1935, M. B. Raizada, Dehra Dun Herb. No. 69335 ! In ravines'.

This species which is common in Jaunsar and Tehri-Garhwal, 3,000–8,000 ft. is occasionally met with along streams and in open ravines as low down as Dehra Dun.

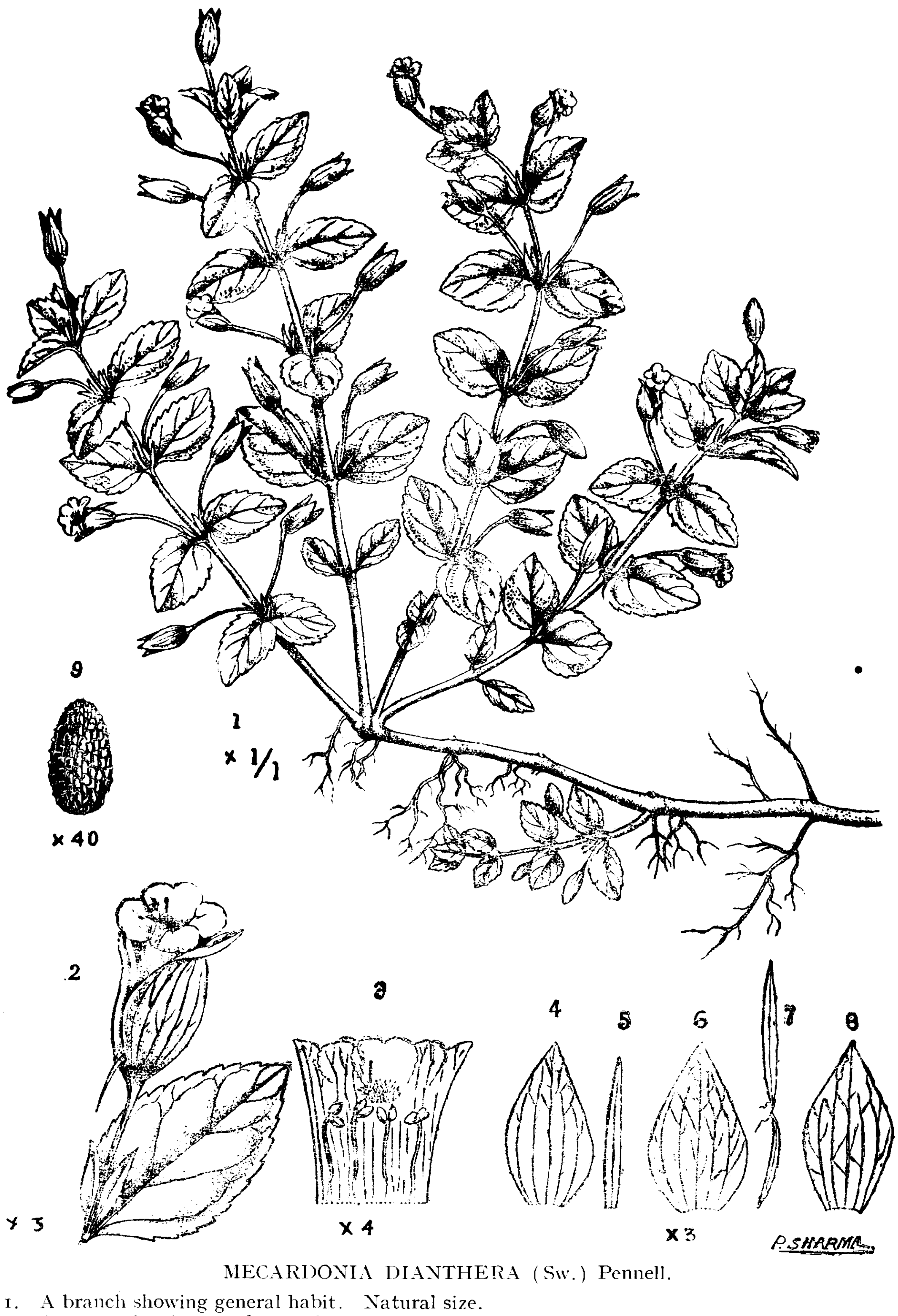
CUCURBITACEÆ

Gymnopetalum cochinchinense Kurz ; Fl. Br. Ind. ii, p. 611.

'Nagwa Gorakhpur dist., 20–4–1898, Harsukh 21417' !

OXALIS PES-CAPRAE, Linn.

1. Entire Plant. Nat. size.
2. Corolla × 1.
3. Androecium × 2.
4. Calyx and gynaeceum × 2.
5. Gynaeceum × 3.



MECARDONIA DIANTHERA (Sw.) Pennell.

1. A branch showing general habit. Natural size.
2. A flower showing two bracteoles × 3.
3. Opened Corolla showing the tuft of hairs in the throat and the four included stamens × 4.
4, 6 & 8. The posterur and two anterior sepals × 3.
5 & 7. Two lateral sepals, one of which has a linear basal appendage × 3.
9. Seed × 40.

The specimen is rather incomplete but is, I think, correctly determined.

It is a pretty climber with deeply cordate orbicular, 5–7–lobed leaves, simple tendrils and small white flowers. Fruit bright orange-scarlet, ovoid-oblong, 2 inches by $1\frac{1}{4}$ inches with 10 strong ribs when young.

It is usually confused with *Trichosanthes* which it resembles in leaves but the tendrils are simple in this species while they are 2–5–fid in *Trichosanthes*. From species of *Cucumis* which have also simple tendrils it can at once be distinguished by the flowers which are white in this species while they are yellow in *Cucumis*.

This species is common in Bihar, Bengal, Assam, Chota-Nagpur, Burma and Sikkim up to 2,000 ft.

Gynostemma pedata Bl.; Fl. Br. Ind. ii, p. 633.

'Near Dehra Dun, Sept. 1882, Duthie'!

A slender, herbaceous climber with simple tendrils. Leaves long-stalked, pedate, usually 3–5 foliolate; leaflets vine-like, ovate-lanceolate, usually oblique, crenate-serrate. Flowers minute, in diffuse long, axillary panicles. Fruit a greenish globose berry, pea-like.

This species is commonly mistaken for *Gomphogyne cissiformis* Griff. but differs from it in having simple tendrils and globose, pea-like fruit while the tendrils are bifid and the fruit is obovoid trigonous in *Gomphogyne cissiformis*.

It is common in Kumaon, Nepal, Assam and Burma.

COMPOSITÆ

Eupatorium glandulosum H.B. & K. Nov. Gen. et Sp. iv (1820) 122.

'New Forest, Dehra Dun, March 1937, M. B. Raizada, Dehra Dun Herb. No. 74161! Naturalized in shady places in our plantations'.

A straggling, perennial branched undershrub, 3–6 ft. high. Branches cylindrical, reddish, densely glandular hairy. Leaves opposite, petioled, rhomboid-ovate, trapezoid or almost triangular, sharply pointed, coarsely serrate above the cuneate base, 1–3 inches long, $\frac{3}{4}$–$1\frac{1}{2}$ inches broad, nearly glabrous above, hispidulous along the nerves and glabrate beneath, obscurely glandular on the petiole, which is 1–2 inches long, and lower surface. Corymbs fastigiate—trichotomous; flower-heads clustered, white, pedicellate, 40–70 flowered, slightly fragrant; receptacle flat; involucral bracts about twenty in two rows, lanceolate, acuminate, striate, glandular—ciliate, mostly subequal, shorter than the florets, with scarious margin and with two well-defined nerves. Corolla—tube white, $\frac{1}{6}$ inch, slender, abruptly dilated. Stylar-arms long and far exserted, divergent. Achenes black, glabrous, 1/10 inch long, slender, crowned by a pappus of 10–12 white scabrid hairs, twice as long.

This plant which is a native of Mexico and Jamaica was introduced in Dehra Dun as a garden plant about 1924. Within recent years it has run wild in shady 'chir' plantations in New Forest. According to Fyson (Flora of the South Indian Hill Stations) it has become abundant and a serious pest round about Ootacamund and is spreading rapidly everywhere, even in Eucalyptus plantations, and quickly covers any abandoned land.

Anaphalis araneosa DC.; Fl. Br. Ind. iii, p. 283.

'Robbers Cave, Dehra Dun, Dec. 1938, M. B. Raizada, Dehra Dun Herb. No. 78466'!

'New Forest, Dehra Dun, 7–10–1948, M. B. Raizada, Dehra Dun Herb. No. 100984 and 100985'!

This is a temperate Himalayan plant which is common round about Mussoorie, 5,000–8,000 ft. Its occurrence in Dehra Dun is presumably due to its seeds having been brought down by water in the streams.

Crassocephalum crepidioides (Benth.) S. Moore in Journ. Bot. 50 (1912) 211 ; *Gynura crepidioides* Benth. in Hook. Niger Fl. (1849) 438 ; Bor. in Curr. Sc. vii (1938) 116.

'New Forest, Dehra Dun, Aug. 1940, M. B. Raizada, Dehra Dun Herb. No. 86011. Apparently introduced with plants brought from Calcutta'.

An erect succulent usually much branch annual herb about 2–3 ft. high. Stem and branches pubescent or nearly glabrous. Leaves alternate, spathulate usually deeply lyrate—pinnatified, sometimes not lobed, mostly petiolate, the upper ones rarely sessile, 1–10 inches long ; lobes acutely dentate, almost glabrous. Capitula oblong, $\frac{1}{3}$–$\frac{1}{2}$ inch long, on long slender pedicels, in a dense or lax corymbose cyme, rarely solitary. Disk hairy with filiform bracts below. Involucral bracts about 15, linear—subulate, glabrous or slightly setulose. Florets all tubular, hermaphrodite or rarely a few outer ones female, limb 5-toothed. Corolla orange-yellow or tinged with purple, shorter than or equalling the pappus. Style-branches slender, tips long, subulate, hispid. Anther-bases entire or subauricled. Achenes narrow, many ribbed ; pappus hairs copious, fine, white.

This species, which is a native of tropical Africa, was first observed by Bor in the plains of Assam at Chardurar in 1931. Since then it has spread all over Assam and various parts of Bengal. It has also been reported from Burma (Parkinson 15665), Darjeeling (Raizada 18558), Bastar State (Mooney 2591) and Kalahandi State, Orissa (Mooney 3250).

In Dehra Dun it made its first appearance about 1940 and is since then invading plantations and getting naturalized. One factor which has undoubtedly a very important bearing on its distribution is its capacity for producing flowers and fruits all the year round, as well as its tolerance towards very diverse edaphic conditions.

ASCLEPIADACEÆ

Cryptostegia grandiflora R. Br. ; Fl. Br. Ind. iv, p. 6.

'Bindraban road, Muttra, 3-3-1943, Range Officer, Dehra Dun Herb. No. 93285' !

This climber which is occasionally cultivated for its flowers in gardens is a native of Madagascar. It has within recent times become naturalized in several parts of the Upper Gangetic Plain, viz., Muttra, Aligarh, Agra, on the ridge at Delhi and near Jaipur (Rajputana) on sandy soils.

Tylophora asthamatica Wight and Arn. ; Fl. Br. Ind. iv, p. 44.

'Delhi, 1924, W. R. Mustoe. Dehra Dun Herb. No. 39359' ! A climber with long fleshy roots.

Hoya longifolia Wall. ; Fl. Br. Ind. iv, p. 56.

'Sansaru Khala, Dehra Dun, 16–12–1900, U. N. Kanjilal s.n. in Herb. Dehra Dun' !

This slender, creeping shrub just enters our area.

Ceropegia angustifolia Wight ; Fl. Br. Ind. iv, p. 72.

According to Charles Mc. Cann all the specimens I quoted under *C. macrantha* Wight in Part 2 of my supplement are referable to *C. angustifolia* Wt.

BORAGINACEÆ

Nonnea pulla Lamk. et DC. ; Fl. Br. Ind. iv, p. 169.

'Ajmer, March 1949, Brahma Dutt Tiagi, Dehra Dun Herb. No. 104326 ! In wheat and Barley fields. Flowers white'.

CONVOLVULACEÆ

Cuscuta hyalina Roth ; Fl. Br. Ind. iv, p. 226.

'Ajmer, August 1947, Brahma Dutt Tiagi, Dehra Dun Herb. No. 99447 ! Very common throughout, mostly on Tribulus terrestris, Achyranthes sp., etc.'

Ipomoea sinuata Ortega ; Fl. Br. Ind. iv, p. 214.

'Adharsh Nágar, Ajmer, August 1949, Brahma Dutt Tiagi, Dehra Dun Herb. No. 104325 ! Naturalized along railway line'.

A native of tropical America, occasionally grown in gardens throughout Northern India and sometimes found as an escape in hedges. Run wild and naturalized near Ajmer.

Ipomoea clarkei HK. f. in Fl. Br. Ind. iv, 734 (in additions et corrections) ; *Ipomoea stocksii* Clarke in HK. f. Fl. Br. Ind. iv, 207 (per error. pro. I. clarkei, non 1. Stocksii Clarke).

'Goona, Central India, King, vide Prain in Journ. As. Soc. Beng. 63. ii, p. 105 (1894) under *Ipomoea stocksii* Cl.'

I have seen no specimens. Apparently a very rare plant. It is a slender twiner growing among grass and has flowers of a fine light yellow colour. It differs from *I. hispida* (Vahl.) R. and S. (*I. eriocarpa* R. Br.), in the leaves, the seeds, and the capsules, which latter are hairy in *I. hispida* and glabrous in *I. clarkei*, while it differs from *I. sindica* Stapf in the leaves and seeds.

SCROPHULARIACEÆ

Macardonia dianthera (Swartz) Pennell in Proc. Acad. Nat. Sci. Philadelphia 98, 87 (1946) ; *Bacopia Chamædryoides* (H.B.K.) Wettst. in Engler et Prantl Natur. Pflanzenf. iv, 36, 76 (1891) ; *Herpestis Chamædryoides* H.B.K. Nov. Gen. et. sp. ii, 369 (1818) ; *Lindernia dianthera* Swartz Prod. Veg. Ind. Occ. 92 (1788).

'New Forest, Dehra Dun, March 1939, M. B. Raizada, Dehra Dun Herb. No. 80214 !'

College of Science, Benares Hindu University, Benares, Rains 1944, A. C. Joshi, Dehra Dun Herb. No. 100360 ! Mostly confined to foot-paths.'

An annual, diffuse, decumbent, glabrous herb ; branches few from the base, 6–12 inches long, prostrate or ascending, often rooting at the lower nodes ; stem 4-angled. Leaves opposite, decussate, almost sessile, ovate, rounded, crenate-serrate, subacute or obtuse, rounded and at times unequal-sided at the base, glabrous above, minutely dotted on the under surface, unicostate, midrib sparsely branched. Flowers solitary, axillary, bisexual, zygomorphic ; pedicel ·25–·5 inch long, as long as or longer than the flower, 3-sided ; bracteoles 2, arising from the base of the pedicel, ·1–·12 inch long, linear lanceolate. Calyx ·25 inch long, green, glabrous, nearly as long as the corolla, persistent free (or almost 5-partite ; ?). Sepals 5 free unequal, posterior and the two anterior ovates 3–5-veined the two lateral linear, 1-veined, enclosed by the larger outer sepals ; frequently one lateral sepal, usually the right one, rarely the left one, or both, provided with a green, linear, basal appendage, which projects beyond the outer sepals and is bent towards the pedicel ; all the sepals are somewhat enlarged in fruit and persist after dehiscence and shedding of the seed. Corolla gamopetalous, bilabiate, very shortly exserted, yellow with purple veins, the colour of the veins most intense towards the posterior side, gradually decreasing in intensity towards the anterior side, the veins of the anterior petal almost colourless ; corolla-tube almost cylindric, neither saccate, spurred or plaited, nearly as long as the calyx ; lobes small ; upper lip outermost in bud, emarginate (notched) ; lower lip 3-lobed, lobes spreading, the anterior slightly notched ; a tuft of hairs on the posterior side in the throat of the corolla. Stamens 4, didynamous, arising from the base of the corolla-tube, included ; filaments slender, filiform ; anther-cells roundish, separate, stipitate, dehiscing by longitudinal slits. Disk prominent, hypogynous, greenish-yellow. Gynoecium bicarpellary, syncarpous ; ovary superior, 2-celled, with numerous ovules ; style slightly dilated at the top but not winged, curved towards the anterior side of the flower near its apex ; stigma entire, blunt. Capsule ·25 inch long, smaller than the enclosing persistent calyx, cylindrical, 2-valved septigfragal ; valves entire or slightly notched at the tip. Seeds numerous minute ; testa reticulate, with light brown meshes and dark brown net-work.

This species is a native of America and is of recent introduction in this country. A few plants of this species were observed here in 1940 in pots in the Botanical Garden, F.R.I., the seeds

having presumably been brought down with pot plants from Sibpur, Calcutta, where it is extremely common. Since then it is spreading in all damp and shady places in New Forest.

The only previous record of this species is from Bengal, Prain Bengal Plant ii, p. 765 (1903) and Rec. Bot., Surv. Ind. 3. No. 2. p. 251 (1905). It is not mentioned by Voiget (1845), who completed his account of the Calcutta plants in 1843 or Hooker in Flora of British India, the last volume of which was published in 1897. Bruhl, Journ. and Proc. As. Soc. Beng. n.s. iv, p. 629 (1910) therefore concludes that this species was probably introduced in this country after 1897. There is also no record of this species by Haines in his Botany of Bihar and Orissa. Recently, however, Mooney has collected it from Surguja State (Mooney 2849 in Herb. Dehra Dun) and records that it is abundant and widespread on grassy banks and in open grassland above 3,600 ft.

ACANTHACEÆ

Thunbergia coccinea Wall. ; Fl. Br. Ind. iv, p. 393.

'Near Company Bagh, Dehra Dun, Jan. 1919, Sohan Lal, Dehra Dun Herb. No. 20265' !

'Bindal Nala, near Chand Bagh, Dehra Dun, Dec. 1938, M. B. Raizada, Dehra Dun Herb. No. 78464' !

'Pawalgarh, Ramnagar div., U.P. 1,400 ft., 17–2–1923, A. E. Osmaston, Dehra Dun Herb. No. 31370' !

This climber which is frequently cultivated in gardens is commonly met with as an escape in ravines near Dehra Dun. According to Osmaston it also occurs in shady ravines and moist localities in the sub-Himalayan tract of the Ramnagar division between 1,000–3,000 ft. but is rather scarce.

VERBENACEÆ

Chascanum marrubifolium Fenzl. ex Walp., Repert. 4, 38 (1845), Moldenke in Fedde Rep. Sp. Nov. 45, 132 (1938) ; *Bouchea marrubifolia* (Fenzl) Schau. in A. DC. Prod. 11,558 (1847) ; Clarke in Fl. Br. Ind. iv, p. 564.

'Ajmer, August 1948, Brahma Dutt Tiagi, Dehra Dun Herb. No. 10300 and 101369 ! A herb 1–1½ ft. high'.

LABIATÆ

Hyptis suaveolens Poit. ; Fl. Br. Ind. iv, p. 630.

'Robber's cave, Dehra Dun, Dec. 1938, M. B. Raizada, Dehra Dun Herb. No. 78933 ! A herb about 3 ft. high'.

'Benares, Aug. 1942, M. B. Raizada, Dehra Dun Herb. No. 94890' !

Salvia coccinea Linn. var. *pseudococcinea* Gray ; Fl. Br. Ind. iv, p. 656. *S. pseudococcinea* Jacq.

'Dehra Dun, Nov. 1898, J. S. Gamble 27439 ! garden escape'.

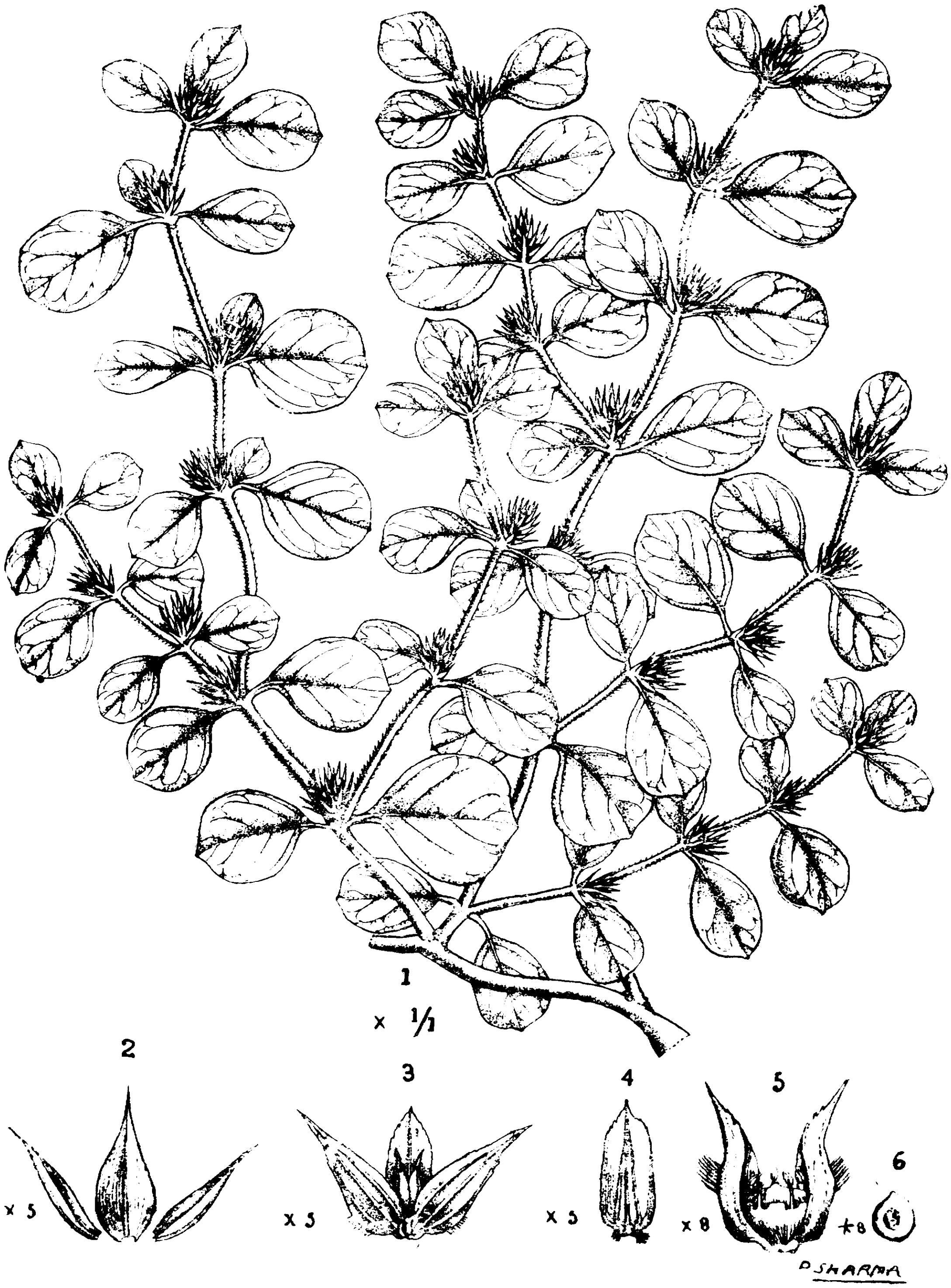
'New Forest, Dehra Dun, April 1939, M. B. Raizada, Dehra Dun Herb. No. 79869 ! Apparently escape, now naturalized as a weed in waste places'.

This species which is a native of Central and South America and frequently cultivated in gardens in India has often been collected as an escape and is now running wild near Dehra Dun. It has long lax erect spike of scarlet flowers about an inch long.

Nepeta bombaiensis Dalz. ; Fl. Br. Ind. iv, p. 661.

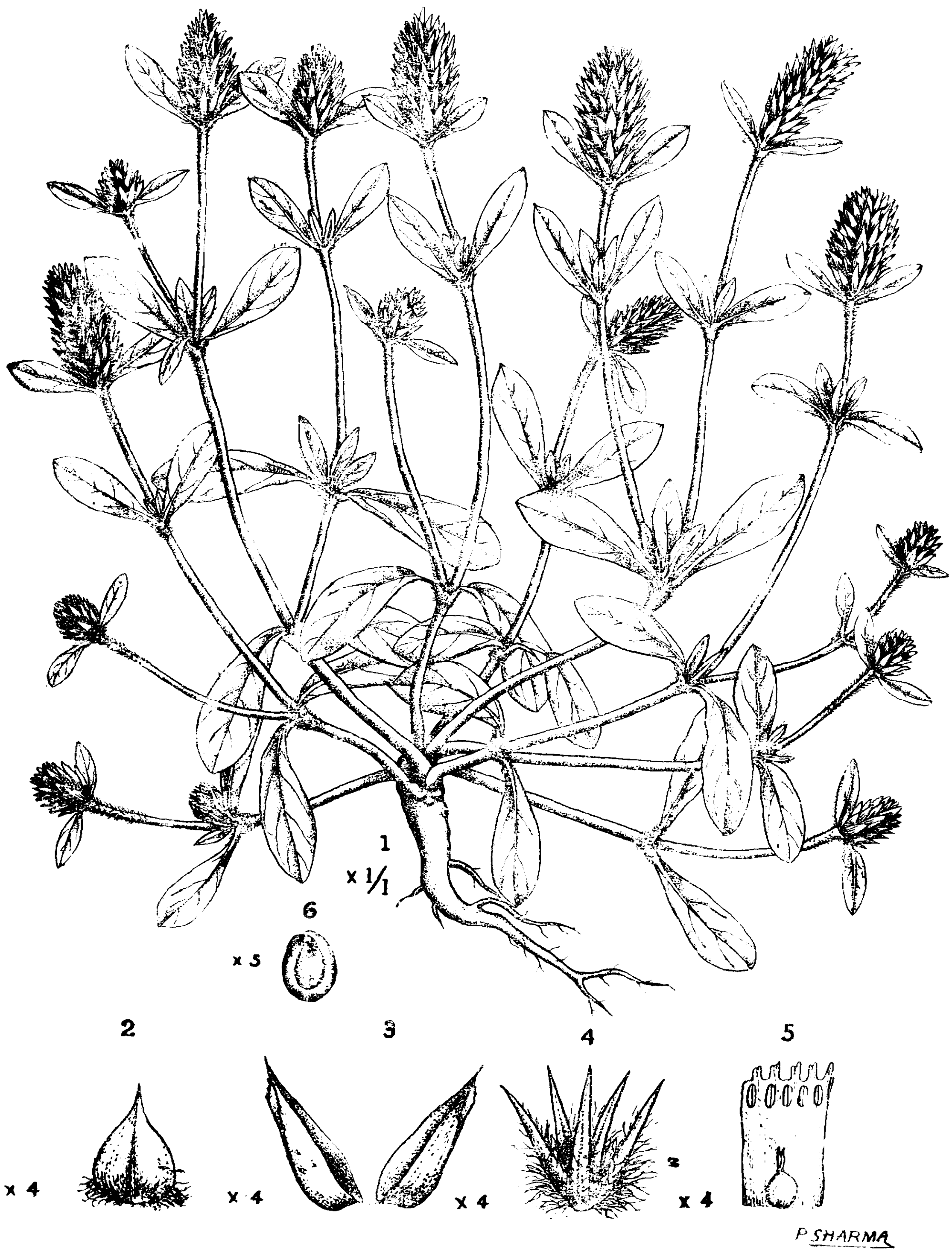
'Bhim, Merwara, 11–1–1886, J. F. Duthie 4838' !

'Ajmer, Lowrie' !



ALTERNANTHERA PUNGENS, H.B.K.

1. Entire plant × 1/1.
2. Bract and bracteoles × 5.
3. Flower × 5.
4. Perianth lobe × 5.
5. Flower showing 5 stamens and two inner perianth lobes × 8.
6. Seed × 8.



GOMPHRENA CELOSIOIDES, Mart.

1. Entire plant × 1/1.
2. Bract × 4.
3. Bracteoles × 4.
4. Perianth × 4.
5. Staminal tube cut open, and Pistil × 4.
6. Seed × 5.

This species was so far misidentified as *Nepeta hindostana* (Roth) Haines (*N. ruderalis* Buch. Ham.), from which it differs chiefly in being more hairy and in the calyx which is about 6–8 mm. long. the upper calyx-teeth being broadly triangular, acute not aristate, while in *N. hindostana* the calyx is about 4 mm. long, the upper calyx-teeth being narrowly triangular, aristate.

AMARANTACEÆ

Alternanthera pungens H.B.K. Nov. Gen. et Sp. ii, 206 (1817) ; *A. echinata* Sm. in Rees Cyclop. Supp. n. 10 xxxix (1819).

'New Forest, Dehra Dun, 18–10–1946. M. B. Raizada, Dehra Dun Herb. No. 98313'. A prostrate weed growing on a heap of brick and mortar, apparently of very recent introduction.

'Ajmer, Aug. 1947, Brahma Dutt Tiagi, Dehra Dun Herb. No. 100961 ! A prostrate weed, common on road sides'.

A prostrate spreading biennial herb. Stem zig-zag, slightly tinged with pink, covered all over with shaggy hairs. Leaves simple, opposite, exstipulate, very unequal ; petiole short somewhat ensheathing at the base ; lamina oblong—orbicular or ovate—orbicular, entire, narrowed at the base, covered with a layer of very short silky hairs, ½–1 inch across, obtuse, or abruptly tipped at the apex. Flowers in heads in the axils of leaves, much compressed and chaffy ; heads ⅓–½ inch long. Bracteoles 2. Perianth-segments of 5 unequal, scarious sepals, 1-nerved ; the outer 3 larger than the inner 2 ; the posterior one oblong, obtuse and furnished with a sharp point at the apex ; the 2 lateral ones lanceolate, sharply pointed at the apex and becoming spiny in fruit ; the 2 inner ones fringed with hairs. Stamens 5, minute, united at the base into a cup and alternate with irregularly toothed processes. Ovary superior, 1-celled, 1-ovuled. Fruit a utricle enclosed by the persistent perianth, the bract and the bracteoles. Seed round, brownish.

A native of tropical America. It was introduced into this country about 1913. This weed was first collected on the Malagiri hills in Salem district, Madras in 1913 and is now rapidly spreading and has already got established in Coimbatore, Bangalore and Madras. It has also been collected from Bombay by Santapau and from Keonjhar State, Orissa by Mooney. I have myself seen it growing at Shahdara near Delhi, at Meerut and in the Indian Agricultural Research Institute grounds in New Delhi.

Owing to lack of literature I have been unable to satisfy myself with the correct identity of this plant as its nomenclature is mixed with taxonomy. Further research is, therefore, necessary to settle this point.

Gomphrena celosioides Mart. in. Nov. Act. Nat. Cur. xiii, 301 (1826).

'Near Birpur, on the banks of the river, Dehra Dun. May 1939, M. B. Raizada, Dehra Dun Herb. No. 80081' !

'Allahabad, Sept. 1944, G. D. Srivastava, Dehra Dun Herb. No. 94895 ! A weed'.

'Ajmer, 27–7–1947, Brahma Dutt Tiagi, Dehra Dun Herb. No. 100962 ! Common along railway side and elsewhere'.

An annual or perennial, much branched, prostrate or procumbent herb. Tap root stout, very long. Branches densely clothed with adpressed or spreading long white hairs ; nodes swollen. Leaves opposite, shortly stalked, entire, oval-oblong, obovate spatulate or oblong-elliptic, 1–2 inches long, attenuate at the base, glabrous above, covered with long white shaggy hairs beneath. Flowers in dense cylindrical, solitary, terminal or axillary spikes ½–1½ inches long. At the base of each spike are two small leaves. Flowers hermaphrodite, dull white, compressed, each with one bract and two bracteoles, Bract short, membranous, ovate, acute, at times denticulate, persistent ; bracteoles as long as the flower, boat shaped, white, membranous and shortly winged on the back at the top. Perianth 5-partite covered with dense white wool, the 2 inner lateral segments larger, concave, woolly, perfectly green along the middle, the 3 outer ones transparent, scale-like, woolly at the base only, Stamenal-tube long, 5-fid, anthers yellow,

1-celled, filaments united into a long tube. Style short, 2-lobed. Fruit enclosed by the hardened perianth. Seed small, somewhat compressed shining, reddish-brown or orange-red, falling away from the fruit on ripening.

Native of S. Brazil, Paraguay Uruguay and Argentina, of very recent introduction but now very rapidly spreading and becoming a troublesome weed on lawns.

Till recently this species was erroneously identified as *Gomphrena decumbens* Jacq. or *G. dispersa* Standley. It can, however, be distinguished from both these species, by the very narrow, often obscure, and entire or scarcely toothed crest on the keel of the bracteoles, which is broadest and appears to rise at some distance below the sharply acute apex. Moreover *G. decumbens* differs in having the bracteoles often tinged with pink and much longer than flowers; while *G. dispersa* has the conspicuous crests of the bracteoles widest at or near the apex so that the flowers have an obtuse facies. Each of these species has a more northern distribution in tropical America, namely in Mexico and Central America, and around the Caribbean Sea. There can of course be no possibility of confusion of *G. celosioides* with the commonly cultivated garden *G. globosa* Linn. which has wider, globose variously coloured heads.

In addition to the localities mentioned above this species has been collected from various parts of India, viz., Madras, Coimbatore, Golapalli, South of Bashar State (Mooney), Ranikhet (Champion) and is now a troublesome weed on lawns in Dehra Dun. I have also seen it in Delhi and Meerut.

Flowers practically throughout the year.

ARISTOLOCHIACEÆ

Aristolochia indica Linn.; Fl. Br. Ind. v, p. 75.

'Saugor, 28–7–1913, D. O. WITT'!

'Ranipur, Banda, 27–10–1920, Shri Ram, Dehra Dun Herb. No. 52479'!

'South Lalitpur, 1–12–1921, Shri Ram, Dehra Dun Herb. No. 52480'!

Also reported from Gorakhpur and Jhansi.

URTICACEÆ

Ficus tsiela Roxb.; Fl. Br. Ind. v, p. 575.

'Ajmer, 1885, A. E. Lowrie 4882'!

'Suna, Deori range, Saugor, 2–3–1915, D. O. Witt 116'!

Doubtless indigenous as it is admitted to be native and sometimes common in the Central Provinces, immediately south of our area.

Ficus clavata Wall.; Fl. Br. Ind. v, p. 522.

'Dehra Dun, Oct. 1890, Duthie 10709'!

'Lakhond, Dehra Dun, Feb. 1896, J. S. Gamble 25672'!

Urtica parviflora Roxb.; Fl. Br. Ind. v, p. 548.

'Dehra Dun, Sept. 1893, J. S. Gamble 24661'!

Common near villages and at times in the forest in moist places.

GNETACEÆ

Ephedra foliata Boiss. Fl. Orient. 5 (1881) 716 var. *ciliata* (C. A. Mey) Stafp.

'Budha Pushkar, Ajmer, 12–2–1948, Brahma Dutt Tiagi, Dehra Dun Herb. No. 101125! Climbing on *Euphorbia neriifolia*'.

According to Parker this tall scandent shrub climbs over small trees and covers them with a dense mass of branchlets similar to *Cuscuta reflexa* at a little distance but of a different colour. It is found in Baluchistan, Sindh, Salt Range, Punjab plains, mainly in the southern portion and is common at Changa Manga in unirrigated places.

ORCHIDACEÆ

Spiranthes Sinensis (Pers.) Ames Orch. 2 (1908) 53 ; *Spiranthes australis* Lindl. ; Fl. Br. Ind. vi, p. 102.

'Chandrabani, Dehra Dun, March 1939, M. B. Raizada, Dehra Dun Herb. No. 81272 ! Near the bank of the rivers'.

'Near Dhakra, Dehra Dun, May 1881, W. Gollan' !

PALMÆ

Wallichia densiflora Mart. ; Fl. Br. Ind. vi, p. 419.
'Garjia Ramnagar div., 1,500 ft., 12–1–1922, A. E. Osmaston 1183 ! A dwarf palm'.

CYPERACEÆ

Cyperus arenarius Retz. ; Fl. Br. Ind. vi, p. 602.

'Ajmer, Aug. 1948, Brahma Dutt Tiagi, Dehra Dun Herb. No. 101596' !

Carex spiculata Boott. ; Fl. Br. Ind. vi, p. 724.

'Karwapani, Dehra Dun, Oct. 1941, M. B. Raizada, Dehra Dun Herb. No. 89791 ! A sedge'.

A SYSTEMATIC CATALOGUE OF THE MAIN IDENTIFIED ENTOMOLOGICAL COLLECTION AT THE FOREST RESEARCH INSTITUTE, DEHRA DUN

PARTS 1–3.—INTRODUCTION; SUBCLASS APTERYGOTA; SUBCLASS PTERYGOTA, ORDER ORTHOPTERA (IN PART), FAMILY BLATTIDÆ

BY M. L. ROONWAL, G. D. BHASIN AND G. D. PANT
Branch of Forest Entomology, Forest Research Institute, Dehra Dun

PART I.—INTRODUCTION

BY B. L. ROONWAL

(a) RAISON D'ÊTRE OF THE CATALOGUE

The Main Identified Entomological Collection at the Forest Research Institute, Dehra Dun (India), comprises to-day (31st July 1950) about 16,651* authentically named species of insects totalling (on an average of 6 specimens to a species) over one hundred thousand specimens of adults. The bulk of this valuable collection consists of "dry" pinned insects stored in dust-proof wooden cabinets charged with anti-insect chemicals such as naphthalene and creosote to keep off Dermestid beetles and other insects which damage dried museum specimens. A small part of the collection, comprising small soft-bodied insects (*e.g.*, the Apterygota, Isoptera, etc.), is kept in glass jars in rectified spirits, while a few specimens are mounted on glass slides.

This collection has been built up during the last half century through contributions made by members of the Branch of Forest Entomology at this Institute, by forest officers in the States of India and by others. Many insects have also been obtained in exchange with other institutions in India and outside. The collection is biassed, as is perhaps inevitable, in favour of forest insects, and is confined largely to the Indian Region, *e.g.*, India, Pakistan, Ceylon, Nepal and Burma, and to a lesser extent Malaya. Many insects, together with the related larvæ, have been bred in the Insectary of the Institute, some larvæ, such as the dry-wood borer, *Stromatium barbatum* (Coleoptera : Cerambycidæ), taking, in individuals cases, as many as 10 years to develop from larva to adult.

The collection has been identified, wherever possible, by the members of the Entomology Branch; otherwise, by specialists in various parts of the world. Hundreds of new species have thus come to light. Until recently, it was unfortunately customary to send the type-specimens (particularly the unique holotypes) of the new species for deposition outside India—chiefly in the British Museum (Natural History), London; but this practice ceased in 1947. While the number of holotypes present is thus very small, there are about 4,629 registered type-specimens of various categories representing 1,136 species and sub-species distributed over 10 orders (Table 1).

TABLE 1.—Number of insect species and subspecies of which the type-specimens (of various categories) are present in the Entomological Collection at the Forest Research Institute, Dehra Dun.

Insect Order	Number of species and subspecies	Insect Order		Number of species and subspecies
1. ORTHOPTERA	9	8. COLEOPTERA		954
		Buprestidæ	74	
2. ISOPTERA	28	Carabidæ	130	
3 ODONATA	5	Cerambycidæ	263	
		Curculionidæ	180	
4. THYSANOPTERA	5	Scolytidæ	62	
		Others	245	
5. HEMIPTERA	24	9. HYMENOPTERA		66
6. NEUROPTERA	3	Braconidæ	37	
		Others	29	
7. LEPIDOPTERA	21	10. DIPTERA		21
		TOTAL 1136		

* The species are serially numbered and entered in three large (*circa* 12 × 16 inches) bound accession registers. The last number in the third register (on 31st July 1950) is 18,787. But to obtain the total number of species, the subtractions mentioned below have to be made from this number on account of the following numbers which have remained either unused or against which no specific identification is given :—(*i*) 1,236 numbers, lying between 1 and 5,000, against which no names are mentioned. (*ii*) 900 serial numbers, *viz.*, 5,100–5,999, which have remained unused. Thus, a total subtraction of 2,136 gives a final figure of 16,651.

In addition to the Main Collection, there are 2 other collections, *viz.*, (*i*) a fairly large Duplicate Collection of adults, maintained chiefly for purposes of general study, exchange, etc.; and (*ii*) an authentic collection of larvæ, in spirit, bred in the Insectary.

Each specimen in the Main Collection bears one or more tiny labels, often printed, giving the scientific name, exact locality and date of collection, name of collector, the ecological habitat (*e.g.*, food-plant, etc.), and usually an R.R.D. (Register of Receipts and Despatch) number, which runs serially for a year*. Specimens bred in the Insectary bear a B.C.R. (Breeding Cage Register) number.

These and other necessary particulars are copied on index cards, arranged alphabetically (species-wise) within each family of insect; they are also copied in the Species Ledger Files, where fuller details may be found. Each species in the Main Collection has a serial number, as already mentioned.

It is desirable that the world should know what we have in the shape of this entomological treasure of considerable scientific importance and economic utility. Innumerable enquiries and requests for identification of insects and advice for control, especially of the forest pests, come to us. Were it not for this valuable reference collection, it would be extremely difficult and in some case impossible to give accurate answers within a reasonable time.

It is pertinent to mention that there are in India two other entomological collections of a like magnitude and scientific importance, *viz.*, the collections of the Zoological Survey of India, Calcutta, and that of the Indian Agricultural Research Institute, New Delhi.

These three collections together comprise a most valuable entomological unit. But large as their combined collection is, it is not enough when we consider the size of the geographical area that it represents. It is not an exaggeration to say that roughly about 40 per cent of the *known* Indo-Malayan species of insects are as yet either unrepresented or inadequately represented in India. As for the hitherto undescribed species, certainly not much less than half the insect fauna of India still remains to be discovered—a stimulating thought for those who may wish to help. The urgent need is twofold : (*i*) To collect insects from all parts of the Indo-Malayan Region and pass them on for study to any of the 3 major entomological centres mentioned above. In this task even amateurs can help, perhaps more than the professionals whose number is inevitably restricted. (*ii*) Young entomologists should try to become specialists in selected groups of insects so that our dependence on foreign countries for assistance in identification may cease.

The contents of none of the three major entomological collections in India have been catalogued, and yet the need for this is only too apparent.

Therefore, at the suggestion of the President, Shri C. R. Ranganathan, M.A., I.F.S., it was decided to prepare and publish, in stages, a complete catalogue of the Main Identified Entomological Collection at the Forest Research Institute. I am obliged to him both for the suggestion and for the encouragement that he has given in the carrying out of this work.

(*b*) SCOPE AND FORMAT OF THE CATALOGUE

The preparation of this Catalogue is going to be essentially a co-operative effort mainly of the members of the Entomology Branch, but help from outside entomologists will be invited and indeed welcomed. The following standard procedure for the preparation and format of the Catalogue will be followed for facility of reference and for binding after the entire Catalogue has been published :—

(*i*) *General*

1. The Catalogue will be published in several parts in the periodical *Indian Forester*. For facility of reference, the pages of all the parts will be serially numbered, beginning with Part 1 and ending with the last part. Each part, as it appears, will also be separately issued as an *Indian Forest Leaflet* (*Entomology Series*).

* It is now proposed to run this number serially over many years until an inconvenient length is reached, as for example 99,999.

(*ii*) *Names and arrangement of Orders, Families, Genera, Species, etc.*

2. The parts will be arranged in a definite entomological order as laid down below. A widely recognized classificatory arrangement will be adopted. For this purpose, it has been decided to follow, as far as possible, the classification given in Imms's *Text-book** (1945). This will apply rigidly to the Orders and Sub-orders and generally also to the Families. But for the lower systematic categories the arrangement given in recently written or revised volumes of the *Fauna of (British) India* series† or in reliable recent monographs and revisions will be followed.

3. The following major subdivisions and orders of insects have been recognized. They will be catalogued in the phylogenetic arrangement given below:

List of Insect Orders to be followed in the Catalogue.—Alternative scientific names are given in round brackets ( ), while the common names are given in square brackets [ ].

Class INSECTA

Subclass 1. APTERYGOTA

Order 1. THYSANURA [Bristle-tails].
,, 2. PROTURA (Myrientomata).
,, 3. COLLEMBOLA [Spring-tails].

Subclass 2. PTERYGOTA

Division I. ***Exopterygota*** (= Heterometabola)

Order 4. ORTHOPTERA [Cockroaches, stick-insects, grasshoppers, crickets, etc.].
,, 5. DERMAPTERA [Earwigs].
,, 6. PLECOPTERA (Perlaria) [Stoneflies].
,, 7. ISOPTERA [Termites or white-ants].
,, 8. EMBIOPTERA.
,, 9. PSOCOPTERA [Booklice & allies].
10. ANOPLURA (including Mallophaga and Siphunculata) [Biting Lice & Sucking Lice].
,, 11. EPHEMEROPTERA (Plectoptera) [May-flies].
,, 12. ODONATA (Paraneuroptera) [Dragonflies].
,, 13. THYSANOPTERA (Physopoda) [Thrips].
,, 14. HEMIPTERA (Rhynchota) [Plant bugs, aphids, etc.].

Division II. ***Endopterygota*** (= Holometabola)

Order 15. NEUROPTERA [Alder flies, lacewings, ant-lions, etc.].
,, 16. MECOPTERA (Panorpatæ) [Scorpion flies].
,, 17. TRICHOPTERA (Phryganeidæ) [Caddis flies].
,, 18. LEPIDOPTERA [Butterflies and moths].
,, 19. COLEOPTERA [Beetles].
,, 20. STREPSIPTERA [Stylops].
,, 21. HYMENOPTERA [Ants, bees, wasps, ichneumons, etc.].
,, 22. DIPTERA [Two-winged or true flies].
,, 23. APHANIPTERA (Siphonaptera) [Fleas].

4. Within each order, the families will also be arranged in a phylogenetic sequence as adopted either in Imms's *Text-book* (1945, *op. cit.*) or in a recent monograph.

5. Within each family, the subfamilies will be arranged alphabetically.

* Imms, A. D. 1945. *A General Text-book of Entomology, including the Anatomy, Physiology, Development and Classification of Insects.* (5th ed.), xii + 727 pages.—London (Methuen & Co.).

† Published, until 1947, by the Secretary of State for India, London; and printed by Francis Taylor & Co., London. Now edited by the Director, Zoological Survey of India, Calcutta, and printed in India.

6. Within each subfamily or family (where there are no subfamilies), the genera will be arranged alphabetically.

7. Within each genus, the subgenera (if recognized) will be arranged alphabetically.

8. Within each genus (or subgenus), the species will be arranged alphabetically.

9. Within each species, the lower or subspecific systematic categories (*e.g.*, subspecies, variety, race, forma, morpha, phase, etc.) will be arranged alphabetically. The relative systematic significance of these intraspecific categories is not always clear. The senior author's account (Roonwal, 1949)* of the modern connotation of these terms may be consulted.

(*iii*) *Names and arrangement of localities*

10. (*a*) The localities of collection of the specimens catalogued under each species, subspecies, etc., will be arranged under 2 main heads, *viz.* : I—INDIA (including India, Pakistan, Nepal, Burma and Ceylon)†. II—Other localities (*Extra-Indian*).

(*b*) Under INDIA, the distribution will be arranged state-wise (within minor lumping) and alphabetically, the names given below being followed :—

Order in which "Indian" localities will be arranged

I—INDIA (including India, Pakistan, Nepal, Burma and Ceylon)

Ajmer (see Rajasthan)
Andaman Islands
Assam, including Manipur and Tripura
Baluchistan
Bengal (East and West)
Bhopal (see Madhya Bharat)
Bhutan
Bihar
Bombay, including Goa, Kutch and Saurashtra, etc.
Burma
Ceylon
Cochin (see Travancore and Cochin)
Coorg (see Mysore and Coorg)
Delhi (see Punjab)
East Bengal (see Bengal)
East Punjab (see Punjab)
Himachal Pradesh (see Punjab)
Hyderabad (in Deccan)
Jammu and Kashmir (see Kashmir)
Kashmir, including Gilgit and Jammu
Kutch (see Bombay)
Laccadive Islands
Madhya Bharat (Central India), including Bhopal and Vindhya Pradesh
Madhya Pradesh (Central Provinces)
Madras
Maldive Islands
Manipur (see Assam)
Mysore and Coorg
Nepal
Nicobar Islands
North-West Frontier Province (N.W.F.P.)
Orissa
P.E.P.S.U. (see Punjab)
Punjab (East and West), including Delhi, Himachal Pradesh and P.E.P.S.U. (Patiala and Eastern Punjab States Union)

* Roonwal, M. L. 1949. Modern trends in systematics.—*Presid. Address to Zool. & Ent. Section, 36th Indian Sci. Congr.* (Allahabad 1949), Part 2, pp. 111–138.

† This arrangement of lumping has been adopted for geographical convenience ; no political significance need be attached to it.

Rajasthan (Rajputana States), including Ajmer
Saurashtra (see Bombay)
Sikkim
Sind
Travancore and Cochin
Tripura (see Assam)
Uttar Pradesh (United Provinces)
Vindhya Pradesh (see Madhya Bharat)
West Bengal (see Bengal)
West Punjab (see Punjab)

(*c*) In the EXTRA-INDIAN category : (*i*) the localities will be arranged alphabetically under the continents, which themselves will be alphabetically arranged ; and (*ii*) within each continent, the countries will be arranged alphabetically. The following names and arrangement of the continents will be followed :—Africa. 2. Antarctica. 3. Arctica. 4. Asia. 5. Australia. 6. Europe. 7. North America. 8. South America.

(*d*) Within each country (or States in "India"), the minor or exact locality (town, etc.) will be arranged alphabetically. Altitudes, in feet above sea-level, will be given as far as possible, except in areas lying in the plains or at very low altitudes.

Example : (The Arabic numerals within round brackets represent the number of specimens of a species present in the collection—see Item No. 11 below).

India.—*Baluchistan* : Quetta (1). *Uttar Pradesh* : Dehra Dun (2) ; Etawah (3) ; Mussoorie, 7,000 ft. (4).

Extra-Indian.—ASIA : *Iraq* (Mesopotamia) : Amara (2) ; Baghdad (3). EUROPE : *Belgium* : Antwerp (1). *France* : Orleans (5) ; Toulouse (1).

(*iv*) *Number of specimens*

11. In a species (or subspecies) the number of specimens from each minor or exact locality (*e.g.*, town, village, etc.), will be added together and the sum written in round brackets immediately after the locality, thus (also see Example under Item No. 10 above) :

Punjab : Ambala (10) ; Ludhiana (7).

(*v*) *Type-specimens*

12. Under each species (or subspecies) the type-specimens will be especially marked and also listed separately, giving full details regarding their locality, date, collector, category of type, etc.

PART 2.—SUBCLASS APTERYGOTA

BY

M. L. ROONWAL and G. D. BHASIN

Subclass 1. APTERYGOTA

Order 1. THYSANURA
(Bristle-tails)

This order is represented by a single species of the family Lepismidæ (Suborder Ectognatha). The other four families, namely, Machilidæ (Suborder Ectognatha), and Campodeidæ, Projapygidæ and Japygidæ (Suborder Entognatha) are unrepresented.

Suborder 1. *ECTOGNATHA*

Family 1. LEPISMIDÆ
Genus *Nicoletia* Gervais

16966. ***Nicoletia cavicola*** Joseph

India.—Punjab : Kotla Cave, Baghal State (1).

Order 2. PROTURA (Myrientomata)
No representatives are present

Order 3. COLLEMBOLA
(Spring-tails)

This order is represented by both the families of the suborder Arthropleona, namely, families Poduridæ and Entomobryidæ ; among these, 4 genera and 4 species are present. The suborder Symphypleona (with the families Neelidæ and Sminthuridæ) is not represented.

The representatives of the suborder Arthropleona are listed below.

Suborder 1. *ARTHROPLEONA*

Family 1. PODURIDÆ

Genus 1. ***Hypogastrura*** Bourlet

16971. ***Hypogastrura armata*** Nicolet

India.—*Uttar Pradesh* : Dehra Dun (large series).

Family 2. ENTOMOBRYIDÆ

Genus 1. ***Cyphoderus*** Nicolet

16970. ***Cyphoderus assimilis*** Boerner

India.—*Uttar Pradesh* : Dehra Dun (13).

Genus 2. ***Lepidocyrtus*** Bourlet

16967. ***Lepidocyrtus orientalis*** Handschin

India.—*Punjab* : Naldera near Simla (3).

Genus 3. ***Paronella*** Schött

16968. *Paronella* ***borneri*** Imms

India.—*Punjab* : Naldera near Simla (large series).

Genus 4. ***Sira*** Tullberg

16969. ***Sira nilgiri*** Denis

India.—*Punjab* : Naldera near Simla (1).

PART 3.—SUBCLASS PTERYGOTA, ORDER ORTHOPTERA (IN PART), FAMILY BLATTIDÆ

BY

M. L. ROONWAL and G. D. PANT

Subclass 2.—PTERYGOTA

Division I. *Exopterygota*

Order 4. ORTHOPTERA

(Cockroaches, locusts, grasshoppers, crickets, stick insects, leaf insects, praying insects, etc.)

This order is represented in the collection by the following 6 families :—

Family 1. BLATTIDÆ (Cockroaches).
,, 2. MANTIDÆ (Praying insects).
,, 3. PHASMIDÆ (Stick insects, leaf insects).
,, 4. ACRIDIDÆ (Locusts and short-horned grasshoppers).
,, 5. TETTIGONIIDÆ (Locustidæ) (Long-horned grasshoppers).
,, 6. GRYLLIDÆ (Crickets).

These families will be catalogued in the order stated above.

Family 1. BLATTIDÆ

(Cockroaches)

The family Blattidæ is represented in the collection by 14 genera and 17 species, all from India ; there are no type-specimens. These are catalogued below.

Genus 1. *Blattela* Caudell

2506. ***Blatella humbertiana*** Saussure

India.—*Bihar* : Pusa (2). *Madras* : N. Arcot : Kottur (Vellore), 3700 ft. (2). N. Salem : Aiyur (3) ; Jawalagiri (3). *Mysore and Coorg* : Fraserpet (2).

Genus 2. *Corydia* Serville

16202. ***Corydia ornata*** Saussure

India.—*Madras* : N. Salem : Jawalagiri (1).

2509. ***Corydia petiveriana*** Linnæus

India.—*Madras* : N. Arcot : Kottur (Vellore) 3700 ft. (6) ; Salem (1).

Genus 3. *Dorylœa* Stål

2507. ***Dorylœa (Stylopyga) rohmbifolia*** Stoll

India.—*Bihar* : Pusa (1).

Genus 4. *Hemithyrsocera* Saussure

16203. ***Hemithyrsocera nigra*** Brunner

[R. Shelford (*Genera Insectorum, Orthoptera, Fam. Blattidæ, Subfam. Ectobinæ*, 1907, pp. 8 and 14), after examination of types, regards *H. nigra* Brun. 1865 as a synonym of *H. palliata* Fabricius 1798. But L. Chopard, who identified our specimens, labelled them as *H. nigra*].

India.—*Madras* : N. Arcot : Kottur (Vellore), 3700 ft. (3) ; N. Salem : Jawalagiri (2). *Mysore and Coorg* : Fraserpet (2).

16204. ***Hemithyrsocera*** sp.

India.—*Madras* : N. Salem : Aiyur (3), Jawalagiri (2).

Genus 5. *Mareta* Bolivar

16205. ***Mareta*** sp.

India.—*Madras* : N. Salem : Aiyur (2 ♂ ♂, 3), Denkanikota (1), Jawalagiri (2), Noganoor (2). *Mysore and Coorg* : Fraserpet (5).

Genus 6. ***Panesthia*** Serville

2511. ***Panesthia 5-dentata*** Kirby

India.—*Madras* : Nilgiri Hills (1).

Genus 7. ***Periplaneta*** Burmeister

277. ***Periplaneta americana*** Linnæus

India.—*Bengal* : Calcutta (1), Dacca (1).

Genus 8. ***Perisphœria*** Burmeister

16206. ***Perisphœria*** sp.

India.—*Madras* : N. Arcot : Kottur (Vellore), 3700 ft. (1) ; N. Salem : Aiyur (1 ♂ , 1), Jawalagiri (1).

Genus 9. ***Phlebonotus*** Saussure

16207. ***Phlebonotus pallens*** Serville

India.—*Madras* : N. Arcot : Kottur (Vellore), 3700 ft. (2 ♂ ♂ , 2 ♀ ♀) ; N. Salem : Aiyur (2 ♂ ♂). *Mysore and Coorg* : Fraserpet (4 ♂ ♂ , 2 ♀ ♀).

Genus 10. ***Polyphaga*** Brullé

2510. ***Polyphaga aegyptiaca*** Linnæus

India.—*Uttar Pradesh* : Mussoorie, 7000 ft. (1).

Genus 11. ***Pseudoglomeris*** Brunner

16208. ***Pseudoglomeris glomeris*** Saussure

India.—*Madras* : N. Salem : Aiyur (6), Jawalagiri (5).

Genus 12. ***Pycnoscelus*** Scudder
(SYN. ***Leucophœa*** Brunner)

2508. ***Pycnoscelus surinamensis*** Linnæus

India.—*Bihar* : Pusa (1).

16209. ***Pycnoscelus*** sp.

India.—*Mysore and Coorg* : Fraserpet (1).

Genus 13. ***Symploce*** Hebard

16210. ***Symploce*** sp.

India.—*Madras* : N. Salem : Jawalagiri (2 ♀ ♀ —1 whole, and wings only of another).

Genus 14. ***Theganopteryx*** Brunner

16211. ***Theganopteryx*** sp.

India.—*Madras* : N. Salem : Aiyur (4), Jawalagiri (2). *Mysore and Coorg* : Fraserpet (7)

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SIAM—THE LAND OF FREEDOM AND MILES OF SMILES

BY M. D. CHATURVEDI

Looking down from the height of about 15,000 feet at which the K.L.M. Constellation enters Siam cruising at about 250 miles an hour, this Land of Freedom, otherwise known as Thailand, has the appearance of a vast stretch of forest covering an exceedingly picturesque region. The configuration of the ground is rugged, cut up by numerous streams which give rise in their southward course to the vast alluvial plain drained by the Mae Nam Chao, its tributaries and distributaries. The total area of the State amounts to about 200,000 sq. miles, 70 per cent of which is under forest. It is interesting to note that while Thailand has an area approximately equal to that of the Uttar Pradesh, Bihar and West Bengal, its population is only 18 millions as against 125 millions of the region of the corresponding size in India.

2. The bulk of the population of Thailand is concentrated in the Central alluvial plain which constitutes the veritable rice bowl of this region. The economy of the country is built round rice, teak, and to some extent tin and rubber. The secret of the prosperity of this land lies not only in what it produces but also in what it does not produce, viz., the plethoric rise in human population.

3. Crossing the Dawna range, forests soon give place to acres upon acres of rice fields among which rises the beautiful City of Bangkok, after about 4 hours of flight from Calcutta. Situated at the head of the Mae Nam Chao delta, this Venice of the East, is the veritable abode of the Goddess of Plenty. Shops are literally packed with foreign goods covering a vast range of commodities typified in Zeiss cameras, Swiss watches, American cars, French silks and western cosmetics. Consumable stores made in India, China, United States, Great Britain and occupied Japan prominently displayed vie with one another. Both food and cloth are cheap and plentiful. The duty on foreign goods is low (20%) and, it would appear, seldom paid.

4. The State religion is Buddhism. People, however, eat beef, shrimps, lobsters and fish but no mutton as a concession to the doctrine of compassion propounded by Lord Buddha. The Buddhist injunction against killing is interpreted by the Thais as against killing for sport, not for food. Religion here is a way of life, not a matter of austere ritual. Temples with their gilstening spires have a bewitching architecture with multiple roofs and golden yellow tiles. The breath-taking Emerald Buddha sits above a 30 ft. high golden structure, in the temple in the palace grounds. Concealed lighting enhances the effect of the statue which is made out of jasper, not emerald. As Buddhas go, it is the smallest idol, no bigger than about 2 feet in height. The priests occupy a place of honour at the State ceremonies. The *Bhikshuks* in their immaculate saffron clothes oblige the giver by accepting alms which they never seek. There are no beggars, nor lepers, nor maimed persons who accost the pilgrims in the temples in India.

5. The Siamese language and culture bear an imprint of the ancient Indian civilization. The story of Ram is depicted in gold on the palace walls. In the Government House reception hall, Vishnu sits with Lakshmi on a throne made out of the coils of a python, with its hood mounting guard on them. The *Garud* is a national emblem. The Kings of Siam are known as Ramas who hail from their former capital Ayothia which was sacked by the Burmese over a hundred years ago, and abandoned in favour of Bangkok. The Indian Legation is on Ayothia road, and our representative is known as the *Rajdhut*.

6. Unlike most capitals in the Orient, the City of Bangkok is neat, tidy and colourful. The Monument of Democracy stands in the middle of the main thoroughfare with modern buildings and liberal pavements on either side. Nearly every house has a pond of its own. A net work of canals winds around the City.

Country boats supplement transport and help solving the housing problem. Quite a large number of people live in boats which are moved from place to place in the water alleys. Modern American cars, Chromium plated cycle rickshaws gaily lighted at night, and boats of all sorts and sizes provide the necessary transport.

7. Of food there is plenty. Rice constitutes the staple diet supplemented by fish and other lower forms of life which abounds in the waters around. A vast variety of luscious fruits and vegetables is within the reach of all. Milk is not a popular food. Even babies are fed on grilled bananas. There are no controls, no prohibition. Foreign liquors, home brews and cigarettes are cheap. Restaurants and food shops attract crowds of people.

8. The people are smart, tidy and have pleasant manners. They are completely westernized. Both men and women adorn European dress. They bathe several times a day. The rich and poor have a flair for well-tailored clothes. No one is fat. Barbers ply a brisk trade. Every fifth girl perms her hair.

9. Nothing seems to go wrong ever. Nothing ever matters. No one ever grumbles. People wear miles of smiles. The bountiful Providance makes people improvident. No one seems to worry or save for the rainy day, may be because it rains most of the time. And when it is not raining outside, it is inside your shirt. There are of course three usual seasons, viz., hot, very hot and d....d hot with steaming humidity thrown in the bargain.

10. Foresters will naturally be interested in the type of vegetation obtaining in Siam. The Thai Forests may be classified as—

(1) Evergreens.

(2) Deciduous.

(1) The evergreen Forests exhibit the following types :—

(*a*) Tropical evergreens. (Below 3,000 ft.) Typified by *Dipterocarpus alatus*. *Hopea odorata*, *Anisoptera cochinchinensis*, *Cedrela toona*, *Schoutenia hypoleuca*, *Semecarpus spp.*, *Artocarpus lakoocha*, *Mangifera coloneura*, *Baccaurea sapida*, *Lagerstrœmia calyculata*, *Bischofia*, *Javanica*, *Michelia champaca*, *Diospyros sp.*, *Eugenia sp.*, etc., with an undergrowth of bamboos (*Dendrocalamus Brandisii*), palms and canes.

(*b*) Hill evergreens. (Above 3,000 ft.) comprise oaks (*Quercus sp.*) chestnuts (*Castanopsis sp.*) admixed with *Schima wallichii*, *Styrax benzoides*, *Michelia champaca*, etc.

(*c*) Coniferous forests. (2,000 to 3,000 ft.) occur in the Northern and Central Thailand from an elevation of 2,000 ft. upwards. The chief species are *Pinus khasya*, *Pinus merkusii* admixed with species of *Quercus*, *Pieris* and *Eugenia*.

(*d*) Mangroves :
are met with in tidal swamps at the mouths of rivers. The chief species met are *Rhizophora sp.*, *Bruguiera spp.* and *Ceriops spp.*

(2) The deciduous Forests may be broadly distinguished into :—

(*a*) Mixed deciduous, the principal species being teak (*Tectona grandis*) which forms the mainstay of the Siamese forests. With teak are associated species of *Pterocarpus*, *Xylia*, *Lagerstrœmia*, *Schleichera*, *Afzelia*, *Adina Terminalia*, *Vitex*, not new to India.

(*b*) Deciduous Dipterocarpus :
Occur in the Northern and Central Thailand rising up to an elevation of 3,000 feet. Typical of these forests are *Dipterocarpus tuberculatus*, *Shorea obtusa*, *Terminalia tomentosa*, *Buchanania latifolia*, *Phyllanthus emblica*, *Holarrhena antidysenterica*.

In addition to the above, there are Beach forests (*Casuarina equisetifolia*) and fresh water swamps forests (*Alstonia*, *Eugenia*, *Barringtonia*, *Saracca*), etc.

11. The wild-life is akin to that of Burma.

12. It was at Bangkok that the Forestry and Forest Products Commission was inaugurated on October 9, 1950 as a result of the recommendations of the Mysore Conference held in

FIG. 1.—Temples of Thailand.

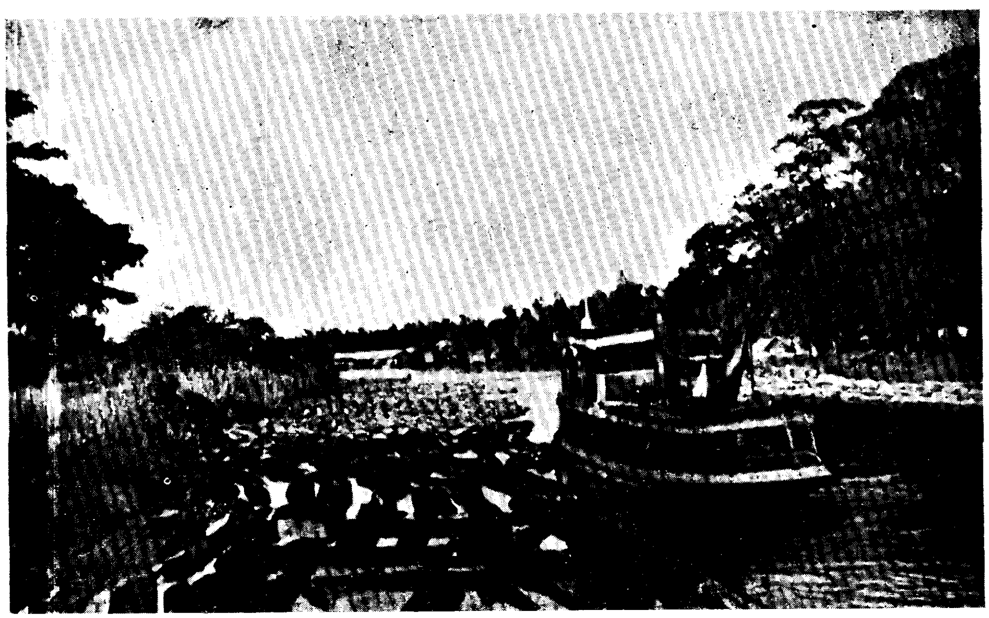
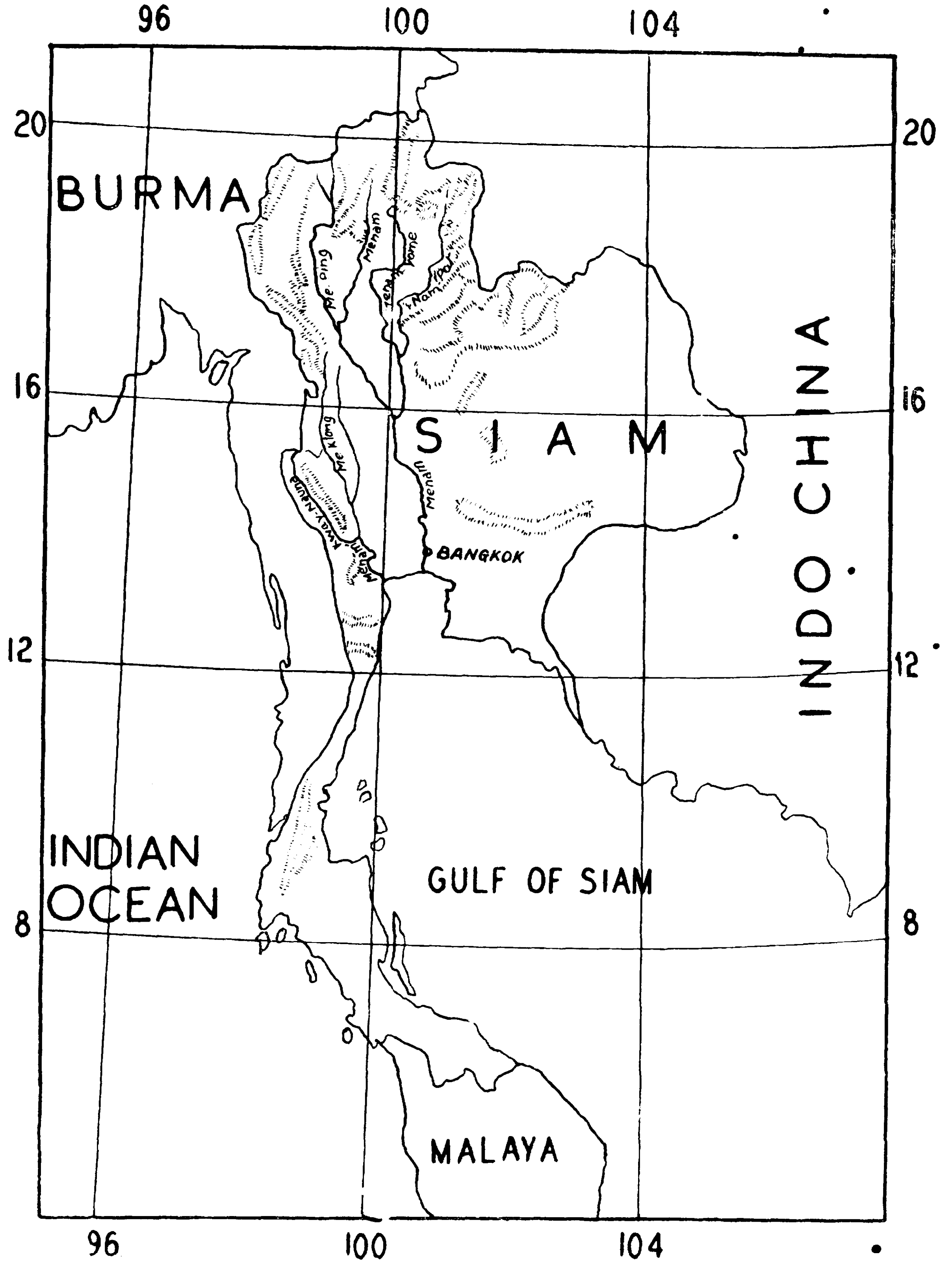


FIG. 2.—Teak logs in the *Mae Nam Chao.*


96
100
104
20
16
12
8
BURMA
SIAM
INDO CHINA
INDIAN
OCEAN
GULF OF SIAM
MALAYA
BANGKOK
Me Ping
Me Klong
Menam

March 1949 under the aegis of the Food and Agriculture Organization of the United Nations. Thirty-three delegates from twelve countries attended the inaugural session which was formally opened by H.E. Phra Chaung Kaset, Minister of Agriculture, Thailand. His Excellency Field-Marshal P. Pibul Songram, Prime Minister of Thailand delivered the inaugural address.

13. Mom Chao Suebsukswasti Sukswasti delegate for Thailand was elected Chairman, and Dr. C. H. Holmes of Ceylon and Shri M. D. Chaturvedi of India were elected as first and second Vice-Chairman. Mr. J. P. Edwards, United Kingdom delegate was appointed as Rapporteur.

14. Resolutions adopted by the Conference dealt with :—

(*a*) Discussion on the action taken on the resolutions of the Mysore Conference led to the following recommendations :—

(1) *Compilation of annual progress* reports.

(2) Setting up of machinery for the exchange of seeds.

(3) Taking up the question of the reduction of shipping rates on the transport of forest products.

(4) Co-ordinating research on pulping of tropical woods.

(5) Provision of information regarding procurement of technical equipment.

(6) Co-ordination of Forest Research and Educational facilities on a regional basis.

(7) Study of problems of shifting cultivation.

(*b*) Acceptance of the Dalat recommendations on standardization with the necessary reservations and modifications.

(*c*) Integration of forest industries.

(*d*) Programme of Technical assistance by FAO.

(*e*) Statement of Forest Policy of the Region.

(*f*) Timber for United Nations Rehabilitation in Korea.

15. A complete report is published elsewhere in this issue of the *Indian Forester*.

By kind permission of the Chief Forestry and Forest Products Working Group for Asia and the Pacific of the Food and Agriculture Organization .

SUMMARY OF REPORT OF THE INAUGURAL SESSION, FORESTRY AND FOREST PRODUCTS ORGANIZATION FOR ASIA AND THE PACIFIC

BANGKOK, THAILAND : *October 9–17, 1950*

I. INTRODUCTION

1. The Forestry and Timber Utilization Conference for Asia and the Pacific held at Mysore, India, in March 1949, recommended the setting up of a Forestry and Forest Products Commission for Asia and the Pacific. The Fifth Annual Conference of the Food and Agriculture Organization, having approved the recommendation in November 1949, the Director-General convened an Inaugural Session at Bangkok, Thailand, and the Commission was officially constituted on 9 October 1950. Thirty-three delegates from twelve countries attended the Inaugural Session which was formally opened by H.E. Phra Chuang Kaset, Minister of Agriculture, Thailand, who was elected Honorary Chairman, and was addressed by His Excellency Field-Marshal P. Pibulsonggram, Prime Minister of Thailand.

2. At the first Plenary meeting on October 10, Mom Chao Suebsukswasti Sukswasti, Delegate for Thailand, was elected Chairman, Dr. C. H. Holmes of Ceylon, First Vice-Chairman and Shri M. D. Chaturvedi of India, Second Vice-Chairman. Mr. J. P. Edwards, United Kingdom Delegate was appointed Rapporteur.

3. The Rules of Procedure prepared by the FAO Secretariat were adopted with some changes. The Commission defined its membership as comprising those countries whom the Director-General shall invite to participate in its work. An additional rule provided for two Vice-Chairmen, who, together with the Chairman and the Secretary-General as Secretary, form an Executive Committee to act for the Commission between sessions. The Executive Committee will keep in touch with diplomatic missions in Bangkok. The provision of an Executive Committee was necessitated by the decision, on the motion of the Delegate of India, that the Commission should meet biennially.

4. The Commission spent four days in hearing oral reports of action taken by Governments upon the resolutions of the Mysore Conference. There was evidence of considerable progress in most countries, despite many difficulties. It is recommended that in future written reports on progress towards implementing these and other resolutions of the Commission should be prepared in conformity with suggested headings circulated by the Secretary in advance of any session of the Commission, thus saving much valuable time.

5. Arising out of the Report of the technical meeting held at Dalat, Vietnam, in April 1950, the Commission decide to establish a Working Party on standardization with M. M. Boucaud, Delegate of the French Union as its Chairman. Two preliminary meetings were held during the Session and the full Working Party will continue its work until the next session largely by correspondence.

6. The statement on "Principles of Forestry" drawn up by the FAO at the request of the Third World Forestry Congress at Helsinkin in 1949 was accepted by the Commission as a minimum on a world-wide basis, and a separate statement defining these principles with regard to Asia and the Pacific was adopted. The Commission approved a program of work for the Commission and its Secretariat and specified certain points in its resolution on action arising from the resolutions adopted at Mysore.

7. It was agreed that the Commission Secretariat should compile statistics concerning timber price trends. It was recognized that it would be necessary for Governments to supply statistical material annually, in line with Resolution XVII of the Mysore Report.

8. During the discussion on the FAO program of technical assistance, of which Member Governments were urged to take full advantage, the value of co-ordinating this program with the bilateral programs of the United States and with the Commonwealth Technical Co-operation Scheme became evident. A resolution recommending such co-ordination was adopted.

9. The Delegate of the United Kingdom on behalf of his Government invited the Second session of the Commission to meet in Singapore and the Federation of Malaya. It was pointed out that the Standing Committee on Forestry of the Pacific Science Congress would meet in the Philippines in 1952. On behalf of the Director-General of FAO, his special representative thanked the United Kingdom for its invitation which the Director-General would take into account when determining the venue of the next session of the Commission. It was suggested that October would be a suitable month.

10. It was noted that FAO is contemplating sponsoring, about October 1951, demonstration courses for the fighting of forest fires, to be organized by the United States Forest Service for the benefit of all countries in the world interested in the problem. While forest fires do not constitute a serious menace in most countries in this region, the delegates of Australia, French Union, India and the Philippines and the observer for SCAP indicated that the countries they represented would be interested in an invitation to these courses.

11. The representative of the Director-General and the observer for SCAP both drew attention to the urgent need for sawn timber, firewood, and charcoal in Korea. The Commission expressed a desire to assist in any way possible, and a resolution to that effect was adopted.

RESOLUTIONS ADOPTED BY THE CONFERENCE

I. MATTERS ARISING FROM THE MYSORE CONFERENCE

The Commission,

HAVING HEARD the reports of the delegations of member countries on action taken by Governments upon the Mysore resolutions,

EXPRESSES its appreciation of the progress which has been made in all countries represented, often in the face of difficulties ;

RECOMMENDS to Governments that they continue to use every effort to make further progress in implementing these Resolutions before the Second Session of the Commission ; and

FURTHER RECOMMENDS that the following points be incorporated in the programme of work to be undertaken by the Commission's Secretariat.

(1) The compilation of annual progress reports from member countries dealing with the place of forestry in the national economy, in particular giving details of forest revenue in relation to the general revenue of the country and in relation to direct expenditure on actual improvement and development of the national forest estate, such as silviculture and other operations to improve the growing stock, enumeration surveys and the construction of forest roads and other extraction facilities, but excluding expenditure on emoluments of permanent staff and other purely administrative charges,

(2) Setting up of machinery for the exchange of forest seeds between member countries,

(3) Taking up with the proper authority the question of reducing shipping rates on the transport of forest products,

(4) Securing co-ordination of research on pulping of tropical woods, setting up, if necessary, a working party for the purpose,

(5) The provision of information covering the procurement of logging and sawmill machinery and other technical equipment in response to specific requests,

(6) A study undertaken if necessary by a working party of the possibility of co-ordinating forest research and using existing research and educational facilities on a regional basis,

(7) A study of the problems of roving agriculture, existing in the different countries of this region, undertaken if necessary by a working party, and the dissemination of information regarding its control.

II. PROPOSED SOIL CONSERVATION CONFERENCE

The Commission,

RECOGNIZING the importance of the problems of soil conservation and erosion and the adoption of control measures,

REQUESTS the Food and Agriculture Organization to consider the possibility of calling, in Ceylon, at an early date, a Regional Conference on Soil Conservation to take the place of the previously proposed Land Utilization Conference, and recommends that forestry authorities be associated with the preparation and organization of this conference.

III. MATTERS ARISING FROM THE DALAT TECHNICAL MEETING

The Commission,

HAVING EXAMINED the Report of the Technical Meeting on Standardization of Nomenclature, Terminology, Testing Methods, Grading and Dimensions of Timber, held at Dalat, Vietnam, April 3-7, 1950,

ACCEPTS the Report as providing the guiding principles in the evolution of common standards for the region, as far as these are practicable ;

RESOLVES to establish a Standing Working Party for continuous consultation on standardization with such sub-committees as may be deemed necessary to examine matters of nomenclature, grading, dimensions and testing methods with a view to :—

(*a*) adjusting the Dalat recommendations to the needs of those countries in the region not represented at Dalat,

(*b*) reducing differences to a minimum,

(*c*) aiming at eventual achievement of common practices throughout the region ; and

RECOMMENDS that if any country intends to export tropical hardwood logs and sawn timber, it should study the North Borneo and Malayan Grading Rules with a view to their adoption, with modification of necessary ; and that those countries who already have an export trade in teak and other hardwoods should, while continuing to use their own established grading rules, also study Seaman-Limaye Teak Grading Rules, the North Borneo Grading Rules for logs, and Malayan Grading Rules for sawn timber, respectively, and conform to them as far as practicable.

IV. INTEGRATION OF FOREST INDUSTRIES

The Commission,

HAVING STUDIED the paper presented by the Delegate of Australia on Integrated Utilization of Tropical Woods,

RECOMMENDS that all Member countries, with FAO assistance, base their immediate and long-range forest management and utilization programmes on the integration of primary and secondary forest industries where possible, aiming, within the limits of economic practicability, at the fullest and most efficient use of all forest products, including the utilization of Logging and manufacturing Waste ; and

EXPRESSES the view that the planning of such a programme involves :—

(1) Obtaining detailed knowledge concerning individual species, whether at present in commercial use or not, in respect of

(*a*) their correct botanical identification,

(*b*) their availability in size quantity and quality and

(*c*) the determination of the properties of their products ;

(2) providing adequate measures to prevent post-felling deterioration due to insect and fungal attack and other degrade ; and

(3) assuring the continuity of supply of speciality timbers and other forest products.

V. PROGRAMME OF TECHNICAL ASSISTANCE

The Commission,

AFFIRMS its interest in the Expanded Technical Assistance Programme of the Food and Agriculture Organization ;

URGES that in order to avoid duplication FAO exert every effort to co-ordinate its programme with Bilateral Programmes of the United States of America the Commonwealth Technical Co-operation Scheme and the programmes of other Governments and International Agencies ; and

EMPHASIZES the importance of organizing, if possible, the training of timber Inspectors in 1951.

VI. STATEMENT OF PRINCIPLES OF FORESTRY

The Commission,

RECOGNIZES that the forest is a factor of the highest importance in the balance of nature. Products are indispensable to man, and their consumption increases with the development of standards of living and the growth of world

population. It is an *indefinitely renewable source of wealth* the rational conservation and exploitation of which is a matter of concern to the world as a whole. Moreover, many countries must depend upon other countries for supplies of forest products. Because it provides or can provide employment for many workers and is a source of raw material to a wide variety of industries in many countries, the forest constitutes an important element in economic and social stability and progress. The forest exercises important protective functions in regard to soil, water and climate and, as a result, influences the agricultural economy, the development of hydro-electric industries and the general welfare of rural and urban peoples, and these protective influences extend for beyond the borders of individual countries. Consequently in order to enjoy to the full the benefits which forests, afford, it is essential that each country should formulate a sound forest policy :

REALIZES that forestry conditions vary widely from country to country. Great differences exist in the forms of forest ownership. Rational exploitation of the forest and economical utilization of its products necessitate the application of varying techniques and administrative procedures suitable to varying conditions ; and

REALIZES, however, that certain basic principles govern for any country both the formulation and the implementation of an adequate forest policy ;

RECOMMENDS, THEREFORE, to Governments the adoption of the following principles :—

PART I

PRINCIPLES GOVERNING THE FORMULATION OF A FOREST POLICY

(1) *Each country should determine and set aside areas to be dedicated permanently to forests, whether at present afforested or not.* This should be done progressively, if necessary, and in accordance with its economic and social policy, especially with regard to land use.

(2) *The people of the country concerned should enjoy in perpetuity the maximum benefits available from the protective, productive and accessory values of the forests at their disposal or which can be created.* This implies that :—

(a) Protection should be afforded at least to all permanent forests against damage or destruction by man or by such causes as fire, insects and tree diseases.

(b) Production should be organized in quantity and quality with a view to obtaining a sustained yield as soon as practicable, and after taking into account any protective or accessory role assigned to the forest, should provide first of all for the needs of the local people and then for the requirements of trade and industry.

(3) *Adequate knowledge of all aspects of forest resources, forestry and the consumption and utilization of forest products is indispensable.* This includes in varying degrees at the different stages of the development of forest policy, a knowledge of the resources available on afforested lands, or of those that could be made available on idle lands ; of the national needs for forest products ; of the natural laws that apply to forests ; and of the techniques employed in the production of forest crops and the utilization of their products. This implies that research will be established and expanded in order to keep pace with all developments in the field, and that the application of the results obtained will be encouraged.

(4) *Public consciousness of forest values should be developed by all means possible.*

PART II

PRINCIPLES GOVERNING THE IMPLEMENTATION OF A FOREST POLICY

(5) *Forest legislation* to give effect to the forest policy should be enacted in consonance with the juridical forms and customs of the country. Such legislation should be developed in keeping with the economic and social progress of the country.

(6) *A forest service* should be established and staffed by suitably qualified personnel in all its grades to administer the forest law, to develop forest policy, to carry out research, and to disseminate its results. Such a service should be formed on a permanent basis and should be endowed with adequate authority and financial support.

(7) *Adequate training* should be provided for all those who will be responsible for the treatment of forests and for the industrial utilization of their products. In particular, foresters and allied technicians must be trained in sufficient numbers to staff public services and other interests concerned with forestry and forest products. For the higher grade personnel such training should be provided at schools of University standard, preferably in the country concerned. Subordinate personnel must receive suitable basic training to enable them to fulfill their duties efficiently.

The Commission,

WHILE ACCEPTING the principles as outline in the foregoing statement, as a minimum world-wide basis

RECOGNIZES, specifically with regard to the Asia and pacific region

(1) the vital role which forests play in the maintenance of the physical and climatic conditions of a country, more particularly their protective influence on the soils and their stabilizing effect on the water regime,

(2) that forests constitute an indispensable adjunct to agriculture which forms the chief occupation of the bulk of the population of most countries in the region,

(3) the part which forests play in the sustenance of industry, maintenance of communications, organization of defence and other aspects of the economic life of a country ;

And also recognizes that

(1) some areas are better suited than others for the growth of trees,

(2) the protective functions of forests not infrequently transcend geographical boundaries of individual countries,

(3) the conservation and rational exploitation of the renewable forest resources of a country is a matter of concern to the whole region ; therefore

Urges the need for

(1) Governments of the region to recognize the intrinsic right of forestry on its own merits to an adequate share of land to be kept permanently under forest. The proportion of land dedicated to forests would depend naturally on ecological, social and economic conditions. However, each country may indicate with advantage what is the minimum forest area considered indispensable for their protective and productive functions for a given physical region,

(2) Governments to consider the problem of land utilization as a whole, not piecemeal. Forestry, it may be remembered, constitutes an integral part of balanced and complementary land use ;

And recommends

(1) that the management of forests in each country should be so directed as to secure their maximum benefits in perpetuity ; and ensure their protective, productive and accessory functions not only in the interests of the existing generation but also in the interests of those to come,

(2) that for purposes of enunciating objects of management, it would be convenient to classify forests according to their principal functions, such as (*a*) 'Protection', (*b*) 'Production' and (*c*) 'Agricultural forests'. The classification is intended to focus attention on the salient features of management and is by no means to be regarded as rigid. For a given class of forest may well fulfill the functions of the other class also. Satisfaction of the rights of user, privileges and the bona fide needs of the local population should be subordinated,

(*a*) to the overriding necessity for maintaining 'Protection Forests' where interests to be protected far outweigh the interests it may be necessary to restrict,

(*b*) to the wider interests such as national defence of the country as a whole in the 'Production Forests' ; and

(*c*) to their own interests in the 'Agricultural Forest', to save these forests from annihilation ;

(3) the adoption of modern methods of forest management and utilization, ensuring closer conversion, varied production and sustained yield ; and

CALLS on each Government to declare its forest policy on the basis of the principles outlined above, in the implementation of which it is necessary to stress the importance of

(*a*) Forest legislation in respect of public and private forests,

(*b*) Creation of a forest service with adequately trained technical personnel,

(*c*) Forest Research and survey of resources,

(*d*) Providing adequate training to all those who exercise responsibility and authority in land use planning and determination,

(*e*) Creation of public consciousness of the value of forests,

(*f*) Allocation of necessary funds for the improvement of forests for which periodic rather than annual provision is recommended,

(*g*) Pursuance of a positive policy for the protection of wild-life whose wanton destruction cannot but upset the balance of Nature. Amenities for recreation which forests provide should not be overlooked.

VII. TIMBER FOR UNITED NATIONS REHABILITATION IN KOREA

The Commission,

RECOGNIZING the urgent need for sawn timber, firewood and charcoal, in Korea for temporary housing and rehabilitation in the war devastated areas ;

AFFIRMS its desire to assist the United Nations authorities in Korea in any way possible and requests the said authorities to supply to the commission details of specific requirements at the earliest possible moment, it being noted that some member countries of the region have stocks of sawn timber available for immediate delivery if shipping can be arranged :

AND INSTRUCTS the Secretariat, in consultation with the Executive Committee, to take all necessary steps.

SIGNED AT BANGKOK, THAILAND, THIS SEVENTEENTH DAY OF OCTOBER 1950.

For the Delegates :	For the Director-General, FAO.
H. S. H. MOM CHAO SUEBSUKSWASTI SUKSWASTI, *Chairman.*	W. H. CUMMINGS, *Regional Representative of the Director-General for Asia and the Far East.*
C. H. HOLMES, *First Vice-Chairman.*	EGON GLESINGER, *Deputy Director, Division of Forestry and Forest Products.*
M. D. CHATURVEDI, *Second Vice-Chairman.*	M. S. HUBERMAN, *Secretary-General.*
J. P. EDWARDS, *Rapporteur.*	

THE MUTILATED QUEEN IN THE SYLVAN FESTIVAL

A Lesson and a Warning for the *Vana Mahotsava*

BY J. N. SEN GUPTA
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Darjeeling, the mutilated "Queen" of hill stations, lies prostrate to-day with broken limbs! From her anguished inner recess, is issued a warning—with a fervent appeal for redress—to the civilized world, against inhuman "raping of the earth", wrought progressively, though sometimes unwittingly, on units of the global surface by biotic factors, through the agency of old and well-known engines of destruction,—viz., fire, grazing, lopping, removal, by felling or otherwise, of most of the vegetation, including even leaf-litter and mould. Nature never forgives wanton rapacity of animals on herself, and all rational beings must beware of that. Her retribution may be slow, but sure.

2. If the agonized tears and voice of mute insensate things could rouse the feelings of man and awaken his good sense, here is a lesson for him in the meandering streams and rivers, now in spate, or the lonely tree with its swinging branches, standing on a desolate precipice heading towards the inevitable crash.

3. It was but an irony of fate, that just a few days before the terrible catastrophe overtook Darjeeling, His Excellency the Governor of West Bengal had eulogized her as the "Queen of Hill Stations", and indeed she was an undisputed "Queen of Nature"! Dame Jealousy seized that dramatic opportunity to strike and disfigure her, with colossal destruction of human lives and property. What, we wonder, were the root causes for Nature's rude behavier,—so sudden and so quick! Was it all unprovoked? To the fatalist, the answer is a simple one, but the imaginative mind must analyse the causes and their effects. Explanations will be many and varied, and the following is one of them from a Forester's point of view, which is offered for what it may be worth.

4. This short note has been provoked by a perusal of the photo-illustrated reports published in newspapers, that are our loop-holes of retreat, Government *communiques*, etc., during the last two months, besides Sri K. C. Bakhle, Chief Commissioner of Railways' statement to the Calcutta pressman on Monday, the 26th June 1950, which gave a detailed description of the damages wrought. The writer has been a fairly regular visitor to Darjeeling for the last quarter of a century, and was intimately connected with the forest administration in the districts of Darjeeling and Jalpaiguri during the last decade. He and his predecessors had, as *ex officio* Commissioners of the Darjeeling Municipality, occasions to warn the local officials and the public against wanton and continual destruction of forests, which latterly were very severe on the opposite side of the Bloomfield Police Lines, and on areas below the Government House, Birch hills, the Hermitage, etc., and the following lines are based on his personal observations of the country-side *vis-a-vis* the physical aspects of the district.

5. The geological formation of Darjeeling hills, its general stratigraphy, rock and soil, as further affected by climatological factors, have to be reckoned with. "If a section be drawn from south to north from the Terai to the Ramam river, through Karsiang and Darjeeling, it will be found that the entire succession of rocks has *prima facie* the appearance of a great synclinal. In the southern part of the section all the strata are inclined towards the north at rather high angles. Towards the centre, the dips are rolling and irregular........and it has been usually assumed that they (tertiary rocks) are faulted against the older rocks......... The dips are uncertain and irregular with several local anti-and syn-clinals........... This (wavy, wellfoliated gneiss) is the incipient stage of the sharp crumplings of a small scale, which are also common, by which the layers are folded completely back on each other".—(*vide* Memoirs of the Geological Survey of India, Volume XI, Part I).

6. The rocks being traversed by numerous planes of fracture due to crushing, disintegration proceeds quicker than is warranted by

hardness. The action of rains and winds is, however, more severe on the southern slopes than on the north. The absence of a firm terrain must, therefore, be recognized as a proper background.

7. The beneficial effect of a permanent forest or vegetative cover on the soil or ground is much too well-known. While, superficially it acts as a sponge in retaining or slowly distributing water and controlling its flow, which could otherwise be subject to a rapid surface run-off over a bare ground with consequent gully and sheet erosions, the forest cover, by its net-work of roots and matting of rootlets below the ground, holds firmly the upper layer of the soil over the disintegrating rock underneath, in the same manner as the interwoven iron metals (e.g., rods, bands or wires, etc.) reinforce the concrete work of sand, stone and cement, etc. Remove the iron nets and the concrete will crumble under the least pressure. Similarly, if the tree cover be removed, which would eventually kill the roots, the upper layers of the soil will soon disintegrate and disappear laying bare the shallow, loose and insecure rocks that will crumble to pieces. This is the usual phenomenon caused by the destruction of tree cover, although in some cases the results may be slow to discern (notwithstanding subterranean fissures), while quick in others, according to conditions of soil, aspect and other attendant factors.

8. Climate, as influenced chiefly by temperature, barometric pressure and wind, rainfall and humidity, and their seasonal variation, does change the character of the soil and its parent rock to a certain extent. But, the biological factors—the direct and indirect influence of the larger animals, particularly man and his domestic animals—have unfortunately been more malevolent than benevolent to the forest, through injurious effects of fire, grazing, removal of grass, green-fodder, lopping, and to some extent, felling of trees for timber and fuel.

9. Of late, the progress of so-called civilization in its post-war craze for an expansion of urban areas, including, of course, the town of Darjeeling for instance, has depleted the forest-clad hills of most of their trees even from the dangerously steep slopes; and, what was once a town of light cottages, built on an artistic style, and, therefore, pleasing to the eye, peeping through tiers of trees or bushes sprinkled over the town, has, during the last few years, been converted to an ill-planned suburb of the Metropolis, closely dotted with heavy concrete buildings and hutments without much green foliage around them. Elsewhere, the once beautiful forests of the Burdwan Raj Estate, near about Sonada and between Ghum and Toong have, during the past two decades, been largely depleted of their trees (by clear-felling), that have not been restocked yet, to the desired extent,—either naturally or artificially ; and, the damage from grazing has been severe in places. With such examples of deforestation laying bare the denuded hills on either side of the cart road, except the few stretches of reserved forests still preserved in folds of hills, it is not, perhaps, difficult to bring home to the public the baneful effects of wanton destruction of forests. Indications are also pretty definite that forests influence floods. The floods in the Tennessee valley and nearer home in the Damodar (in our own State) are outstanding illustrations of the effects which are caused by the destruction of forests in the hilly country. In the United States of America, hundreds of millions of dollars have been, and are being, spent on re-afforestation, on engineering works for the control of floods in rivers and on the reclamation of agricultural land by terracing, contour-ridging, draining, gully-control and the construction of diversion ditches, dams for storing water and channels for spreading it. Such measures are far too costly to be practicable in West Bengal, but some thing may, perhaps, be done by way of re-afforestation of areas denuded of tree growth.

10. Sri Bakhle has stated that according to estimates, there had been 48 inches of rainfall in the area during 43 hours,—a phenomenon unprecedented in the history of many years and that this made the torrential Tista swell far beyond the normal flood level within living memory. As a result of the heavy flood, the Tista is reported to have swept straight through a forest after passing the Sivoke bridge and, but for the presence of a thick and big forest on the north of Jalpaiguri, which held up the turbulent Tista during the flood, the whole of Jalpaiguri town would have gone. He also mentioned that most of these jungles that lie on the west bank of the river between Sivoke and Jalpaiguri were gone, and all these forests were supposed to have been very old with 70 to 80 feet long trees growing in it in abundance.

11. Heavy and continuous rainfall for two or three days at a stretch is not an uncommon phenomenon in the sub-montane regions of the Eastern Himalayas. It is the rapid run-off of accumulated rain-water from the adjoining basins that has to be checked and controlled. Now, for the purpose of controlling floods in the Tista river, the doctoring has to be done, not so much in the district of Jalpaiguri, as much further up in the district of Darjeeling as well as in the State of Sikkim,—especially, where the denuded flanks on either side of the river have to be re-afforested quickly with a bold policy. The forest belts on either side of the Tista, situated within the district of Jalpaiguri, e.g., the Baikunthapur Raj forest on the right bank and the Apalchand reserved forest on the left, are bound to suffer during the floods by a lateral pressure of the increased volume of water, sometimes to the right, sometimes to the left, unless the Tista river is properly harnessed in the upper reaches.

12. Whether it is a case of land slides or of floods—large or small—our prescription for counter-acting this growing menace is a firm policy of re-afforestation of areas—especially water basins that have been denuded of tree growth. It is a happy augury that the attention of the whole country has already been focussed on the beneficial effects of tree-planting on a large scale, which was first celebrated, during the VANA MAHOTSAVA or Sylvan week early in July, since extended up to the end of this month. Though we have no readymade specific for restoring hair on the bald head overnight, yet our slogan for Darjeeling should particularly be, for the next few years, GROW MORE TREES. Along with it, the present pernicious system of cultivation, potato for example, year after year, without making terraces and thereby loosening the soil that is drifted by the slightest pressure of wind or surface run-off (of which the 'Alubari' basti is but an example) must also be stopped by an organized propaganda (with the help of cinematograph) amongst the agricultural population. Terraced cultivation and stall-feeding of domastic cattle should be brought home to the hill tribes.

13. If the "Queen" has to be restored to her pristine glory and eminence, the district of Darjeeling, along with its neighbouring State of Sikkim, needs a bold policy of re-afforestation with, of course, an eye to the agricultural needs of the population. I commend this to the organizations engaged in rebuilding Darjeeling and her popular hill stations dotted all over the district, and conclude with the following wishes of the Ministry of Food and Agriculture, Government of India :—

> "Celebrate VANA MAHOTSAVA. During this festival week (period) heralding the monsoon, every man, woman and child is called upon to plant a tree. Plant trees in their hundreds of thousands. Water them, rear them until every waste land and open ground is transformed into a sylvan glade".

JAI HIND.

REVIEW OF SOME NAME CHANGES IN INDIAN GRASSES

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The *Gramineæ* excels all other natural orders of the Phanerogams in taxonomic and nomenclatural complications. In this group cases are not uncommon, where species, since their birth, have been designated by more than a dozen different names. The increasing interest of systematists in this group of plants, all over the world, is resulting on the one hand in solving many of the complex problems, and on the other in adding more and more names to the lists of synonyms.

This note is intended to review some name changes in the grasses suggested by Dr. J. Th. Henrard of the Rijksherbarium, Leiden, in Blumea, Vol. IV (1941), a copy of which has only recently reached us. An earlier part of his work, which appeared in Blumea III (1940), was reviewed by Bor in the pages of Current Science IX, 1940, 431–432. Since, Blumea is not readily available to botanical workers in India, it is thought that a useful purpose will be served by making Dr. Henrard's findings, so far as they concern India and Burma, accessible to agrostologists in this country. Hence, a brief account of some name changes of the Indo-Burman species is given here.

We have, in most cases, started from Hooker's Flora of British India, VII, and briefly discussed thereafter, the changes suggested by Henrard.

Bromus unioloides H.B.K. was introudced in India as a fodder grass, and is recorded in Fl. Br. Ind. VII, 357, as an escape from various localities. It has now become naturalized in the Eastern Himalayas. This grass has many-nerved keeled glumes. Dr. Henrard has transferred it to the genus *Ceratochloa*, as *Ceratochloa cathartica* (Vahl.) Henr. based on *Bromus cathartica* Vahl.

Bromus inermis Leyss. (Fl. Br. Ind. 357) is a perennial grass of the Western Himalayas. This has been transferred to *Zerna* under the name *Z. inermis* (Leyss.) Lind.

Bromus asper Murr. (Fl. Br. Ind. 358) is a grass of mountainous regions. It is same as *B. ramosus* Huds. and has to bear the name *Zerna ramosa* (Huds.) Nevski.

Bromus himalaicus Stapf (Fl. Br. Ind. 358) is reported from temperate Himalayas, and now becomes *Zerna himalaica* (Stapf) Henr.

Bromus patulus Mert. and Koch. (Fl. Br. Ind. 361) is found in the Western Himalayas. Its correct name is *B. japonicus* Thunb. This has glabrous spikelets. Its variety with densely villous spikelets was named by Ascherson and Graetsner as var. *velutinus*, based on *B. velutinus* Nocc. and Balb. (1816). This specific epithet is invalid due to its preoccupation in 1806 by Schrader, and a new name was given by Stapf, viz., var. *vestitus* based on *Bromus vestitus* Schrad. Hooker has included *B. velutinus* Nocc. et Balb. in synonymy of *B. patulus*. Henrard, however, regards it as a separate variety, namely—*Bromus japonicus* Thunb. var. *vestitus* (Schrad.) Henr.

Hooker (l.c. 33) describes *Panicum ambiguum* Trin. from Burma and Ceylon. This grass has also been collected from Goalpara, Assam, and later got the name *Brachiaria paspaloides* (Presl.) Hubb. (Bor-Flora of Assam, V, 273). It is more or less glabrous.

Another grass which is widely distributed in India is referred by Hooker (l.c. 33) as *Panicum prostratum* Link. Stapf transferred this to *Urochloa* and named it *Urochloa reptans* (L.) Stapf, based on *Panicum reptans* L. Henrard has named this grass as *Brachiaria paspaloides* (Presl.) Hubb. var. *tomentosa* Henr.

In this connection it is, however, worth noting that the descriptions of Stapf and of the various Indian authors do not show the grass to be so hairy as remarked by Henrard "Densely tomentose".

Hooker (l.c. 162) describes a species *Elionurus hirsutus* Munro, based on *Saccharum hirsutum* Forsk. Boisser [Diagn. Pl. Nov. Or. Ser. II, 4 (1859) 145] noted that this grass was very different from any other so far known and could not conveniently fit it in any genus ; he suggested a new genus *Lasiurus*. The name *Lasiurus hirsutus* (Forsk.) Boiss. was consequently universally accepted. Henrard points out that the plant collected by Stocks from Sind, and so far included under

Lasiurus hirsutus is different from the rest in the nodes being pubescent and culms being puberulous above. He separates the Sind plants as a distinct species, to which he gives the name *Lasiurus scindicus* Henr., thus adding one species to the grass flora of India.

Rottbœllia striata Nees (Fl. Br. Ind. 157) was transferred to *Cœlorhachis* by Camus. Hooker mentions two subspecies *genuinus* Hack. and *khasianus* Hack. This subsp. *genuinus* includes two varieties *glabrior*, and *pubescens*. The latter has been named *Coelorhachis striata* (Nees) Camus var. *pubescens* (Hack.) Henr. This is found in Khasia mountains. Henrard has suggested raising the subsp. *khasianus* to specific rank, thus making the combination *C. khasiana* (Hack.) Henr. He, however, seems to have overlooked the earlier publication of this combination by Bor in Ind. For. Rec. n.s. (Bot.) I, 3 (1938) 101, under the name *Coelorhachis khasiana* Stapf ex Bor. This grass is common in Khasia and Jaintia hills.

Ophiuros corymbosus as described by Hooker (l.c. 160) is composite and much amplified compared with *O. corymbosus* Gaertn., which is based on *Rottbœllia corymbosa* Linn. f. (1781). Due to an earlier name *Aegilops exaltata* Linn. (1771) the name of this grass became *Ophiuros exaltatus* (L.) *O. Kuntze*. Stapf in 1917 (Fl. Trop. Africa, IX) separated a species *O. megaphyllus* as being very robust (1·5–1·8 m. tall), and having leaves ensiform and very hairy. Henrard points out that Elmer in 1915 described a species *Rottbœllia Tongcalingii*, which is the same as Stapf's species. Elmer's species has priority of publication, and henceforth *O. megaphyllus* Stapf should be referred as *Ophiuros tongcalingii* (Elmer) Henr. The *Ophiuros corymbosus* as treated by Hooker includes both *O. exaltatus* and *O. tongcalingii*.

Pollinia articulata Trin. (Fl. Br. Ind. 109) has now become *Pseudopogonatherum contortum* (Brongn.) Camus, based on *Pogonatherum contortum* Brongn. Hackel has described its 2 subspecies and many varieties, of which all are not found in India. Regardless of this fact, Hooker has included all possible synonyms available to him from Hackel's description of this species proper or its varieties. Obviously, the conception of Hooker's description becomes much amplified. Particularly we note the mention of *Pollinia setifolia* Nees, *Andropogon koretrostachys* Trin. and *A. asthenostachys* Steud. Hooker overlooked the fact that these three were given by Hackel as synonyms of his subsp. *fragilis* var. *setifolia*, a grass which is found in the Philippines and China, and is so far not known to us from India. Henrard has now raised it to a specific rank as *Pseudopogonatherum koretrostachys* (Trin.) Henr.

Hooker described a grass under the name *Anthistiria arguens* Willd. (Fl. Br. Ind. 211) from Malacca and the Andamans ; and *Anthistiria ciliata* L.f. (Fl. Br. Ind. 213) from continental India ; the former was regarded the same as *Stipa arguens* L. On a re-examination of the type of *Stipa arguens* L., Merrill discovered that it was the same as *Anthistiria ciliata* L.f. and the true *Anthistiria arguens* Willd. The grass from Malacca and the Andamans was found to be different from them and was later discovered to be *Anthistiria frondosa* Br. Both these grasses were then transferred to *Themeda* as *Themeda arguens* (L.) Hack. and *Themeda frondosa* (Br.) Merr. *T. arguens* (L.) Hack. is found all over India and is described in various Indian floras under different names, which now form a long list of synonyms, viz., *Stipa arguens* L., *Andropogon quadrivalis* L., *And. nutans* L., *And. scandens* Roxb., *And. semiberbis*, *Anthistiria arguens* Willd. and *Anthistiria ciliata* L.f.

Apocopis wightii Nees (Fl. Br. Ind. 142) was first accepted by Hackel, but Henrard points out that this name has to be abandoned for want of valid publication. Steudel, while describing *Andropogon courtallumensis* Steud. made mention of *Apocopis wightii* Nees *MSS.* as synonym. Steudel's name will, therefore, have to be adopted, and now this becomes *Apocopis courtallumensis* (Steud.) Henr. This is perennial.

Following Hackel, Hooker has described subsp. *mangalurensis* under *Apocopis wightii*, from the Deccan. It was based on *Amblyachyrum mangalorense* Hochst. Henrard revives the species and makes the combination *Apocopis mangalorensis* (Hochst.) Henr. This grass is an annual.

While treating *Arthraxon ciliaris* Beauv. Hooker (l.c. 146) gave three groups of its varieties. Typical *A. ciliaris* Beauv. is characterized by glabrous joints of rachis. The

variety with hairy joints was named *quartinianus*, and was regarded by Nash as a distinct species, *Arthraxon quartinianus* (Rich.) Nash. Blatter has adopted Nash's view. An allied species *Ar. hispidus* (Thunb.) Makino was till recently confused with *Ar. ciliaris* and *Ar. quartinianus*. Later authors rather, reduced these three to *Ar. hispidus*, Makino. Henrard pointed out that these three are distinguishable as follows :—

Joints of rachis hairy—	.. *Ar. quartinianus*.
Joints of rachis glabrous—	
awn perfect—	.. *Ar. ciliaris*.
awn imperfect—	.. *Ar. hispidus*.

Occurrence of these three species in India can be decided only on re-examination of the entire Indian material, all of which was so far regarded belonging to one species alone. Henrard has remarked for *Arthraxon hispidus* (Thunb.) Makino "inhabitant of Japan and China"; and for *Ar. ciliaris* Beauv.—"has a wide range".

Hooker has included *Batratherum echinatus* Nees in synonyms of *Arthraxon lanceolatus* Hochst. Henrard points out that *Batratherum echinatus* was based on *Arth. ciliaris* subsp. *quartinianus* var. *hookeri* Hack. (from Sikkim). He has regarded it as separate species *Arthraxon hookeri* (Hack.) Henr., thus adding one more species to our grass flora.

Andropogon zeylanicus Nees ex Steud. (Fl. Br. Ind. 192) was named by Thwaites as *Chrysopogon zeylanicus* (Nees) Thw. Henrard has referred to Steudel where another species, *Andropogon nodulibarbis* Hochst. ex Steud. is described, and which is the same as *And. zeylanicus*. *Andropogon nodulibarbis* which is No. 423 of Steudel has priority of place over *And. zeylanicus* (No. 426). Henrard has, therefore, given the name *Chrysopogon nodulibarbis* (Hochst.) Henr. for this grass.

GREAT OBSERVATIONS OF GREAT MEN

MONEY spent on fundamental research is not money wasted on empty prestige, but is a good and necessary investment which progressive nations will do well not to grudge. When we reach a critical point in anything it is only science that can help.

It would be unwisdom to limit scientific research. It is a good investment to give as much as we can to eminent men devoted to the cause of searching truth....Research is most often a game of finding the needle in the haystack. Scientists may seem to be idling their time and wasting plenty of money. But the needle can be found by some one if many are engaged in seemingly profitless work.

H.E. Sri C. Rajagopalachariar.

CULTIVATION OF WILLOWS AND POPLARS IN LAHAUL

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SUMMARY

Lahaul—a dry tract lying above 9,000′—has few forests and there is acute scarcity of firewood and timber. Tree growth being very slow under natural conditions we have to look forward to sources other than the so-called forests in Lahaul to meet with the existing and increasing demand of firewood and timber. Willow and poplar plantations seem to be the only practicable, effective, and immediate solution of our difficulties. Both the species can be grown without difficulty and there is considerable scope for their cultivation and extension in the Valley.

Introduction.—The most striking feature of Lahaul is the planting of willows along water channels (Kuhls) and moist ground near water springs and streams. The species planted is almost always the crack willow—*Salix fragilis*. Other species which are found in Lahaul are *Salix viminalis* and *Salix insignis*. The willows apparently grow excellently all along the cultivated belts below *Khokhsar* in the Chandra and below *Sumdo* in the Bhaga valley. Each village has its own grove of willows and considers it the most important part of the village economy.

Recently poplars have also been introduced. There are 3 poplars in Lahaul—the pyramidal or Lombardy poplar (*Populus nigra*) introduced from Kashmir, phals or Himalayan poplar (*Populus ciliata*) introduced from Kulu and balsam poplar (*Populus balsamifera*). Although some contend that balsam poplar is exotic it is doubtful as it certainly grows wild in inaccessible places. Lombardy poplar grows well in Chamba Lahaul and is widely cultivated in Zanskar and Ladakh (Kashmir) where it is the only timber tree and cultivation of this is now being fostered in Lahaul as well.

Soil and water requirements.—Apparently willow and poplar grow in any place where they get their roots in water. The writer has seen them planted in mere shale near nullahs and pure sand in the bed of Chandra. But generally nothing is more important that the soil and water conditions suited to the growth and production of willows and poplars. Success in their cultivation will depend entirely on the choice of suitable locality. Clayey and gravel soils are not suitable and should be avoided as far as possible. As regards water requirements both willows and poplar thrive well under water saturated conditions of soil provided the water is in a state of movement. Generally, however, they prefer a deep, well drained and permeable soil on the edge of a stream. In no case should they be grown on permanently water-logged and marshy beds. Reclaimed swampy soils which are rich in alluvium and are subject to flooding are, however, very suitable for their cultivation.

Planting technique.—Planting is done during spring after the melting of snow, i.e., during March–April. It is a bad practice to plant at any other time for setts put in at other periods generally do not survive. Bunches of 4–5 setts (large cuttings) are generally planted during this period at varying distances depending upon local conditions. Generally, however, the Bunches are at a distance of 15–20 feet. The reason for planting 4–5 setts at one place in the form of bunch is not far to seek. The areas earmarked for planting are not closed to grazing of cattle and the soft and fresh bark of willow and poplar forms a great attraction for cattle, sheep and goats who completely or partially strip off the bark of the cuttings. In order to save cuttings or inner parts thereof from this damage 4–5 setts are put together. This method is very wasteful in so far as the number of cuttings used is concerned but is comparatively cheap and is now an established system in Lahaul. In view of the high prices which Zamindars now ask for cuttings and to their being altogether unobtainable elsewhere —the Zamindars are very reluctant to part with them, it is desirable that the old method should be changed and only one or two setts used in one place. This will not only meet the difficulty noted above but also make it possible to cover a larger area in shorter period.

Setts should be fast grown, bearing natural heads of branches and free from any disease or

cut and should be about 12 feet long when planted. The setts should be obtained from pollards or stools and not from side branches, as such do not generally do so well. Setts are then planted in holes dug up to 2–3 feet depth. Care should be taken to secure close contact with soil by beating earth in order that minimum movement of parts of the stem burried occurs and the new shoots are not damaged by action of wind in spring.

Willows and poplars grow well when given plenty of space for their development. Best results are obtained with an espacement of 15′ and 20′ for poplar and willow respectively. In case of planting on both sides of a stream (the trees on one alternating with those on the other) the distance may be kept 20′ and 25′ respectively.

Tending and protection.—On account of edible character of the bark in early age it is necessary that willows and poplars are protected against damage by cattle, sheep and goats. Neglect of this may cause utter failure of the cuttings. Consequently it is desirable that the area taken up for plantation is closed to grazing and if that cannot be done then individual setts or branches should be protected by wrapping pieces of gunny bags around the setts or providing woven plain wire or stone walls. Cost of these operations should not matter if success is to be assured.

Protection of cuttings or setts is the most important consideration in raising willow and poplar plantations. Barbed-wire fancing is impracticable in view of difficulties of obtaining barbed-wire, high cost of transport of the same to Lahaul and non-availability of posts. Provision of wire protection to individual branch or setts is just as costly and impracticable. Construction of protection wall in some places where stone is readily and cheaply available and the ground is not too steep, is practicable but in view of the extent of the problem involved this cannot be undertaken. Perhaps the cheapest and most practicable metod of protection of areas of reasonable extent will be to keep plantation guards during season to assist the beat guards. In this case the plantation guard can also look to the maintenance of water channels and irrigation of plants. It will only be necessary to provide protection in the first 4–5 years of the plantation and can easily be dispensed with at later age.

In about 4–5 years' time the setts that are tied together in a bunch start forming a single trunk and in about 10 years attain a height of 15 feet with dense foliage. Lopping of the shoots is done at interval of 3 years and the bark and the minor twigs are used as fodder and woody portion of shoots as firewood.

Future.—There is considerable scope for extension of willow and poplar plantations and this needs to be encouraged by all means as it is the only practical way of meeting the acuet fuel shortage in Lahaul. Further in dealing with erosion in Lahaul, particularly near streams and rivers it seems to the writer that the best weapon is the willow planting and to some extent the poplar planting. The writer feels certain that if these species were systematically propagated line by line, from favourable to unfavourable sites very large areas at present unproductive and eroding could be brought under tree growth and stabilized. For instance if one or two lines were planted along a stream or water channel on southerly or westerly aspects they would in a year or two provide shade and make it possible to plant more under the shade.

The Lahaul villager is known for and has in many ways shown an exceptional ability to see the value of new ideas and this is amply proved in case of willow groves. Without direction from administration he is rapidly increasing the number and area under willow, but his resources are limited. Moreover what is required now is a systematic and extensive work in this regard which only a Government Agency can undertake. Proposals for Demarcation of such areas are under consideration of the Government. In the meantime some means of encouraging and promoting the activity of people in respect of willow and poplar plantations should be devised. Perhaps monetary grants to cultivators would be most suitable and serve the purpose. The scheme of increasing firewood and timber resources of Lahaul will be launched soon and will be pursued not only on Government lands but Zamindars will also be persuaded to grow willow and poplar on land suitably situated. The idea is feasible and in every way excellent as it will encourage tree planting for timber and firewood and there is plenty of land outside cultivation suitable for the purpose.

REVIEW OF GROW MORE FOOD (SOIL CONSERVATION) PROGRESS OF THE FOREST DEPARTMENT, PUNJAB

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The soil conservation schemes carried out in the Punjab are both development and Grow More Food schemes ; development in the sense that they improve eroded and denuded areas making them more stable and more fertile for production of trees, grasses and field crops. And they are Grow More Food schemes in having raised the water-table throughout the sub-mountain region in a strip with a width of several miles along the entire length of Siwaliks. These schemes have enabled irrigation of some lands where wells had gone dry and made better irrigation possible elsewhere.

The soil conservation measures consist in carrying out one or more of the following works :—

(*a*) Check damming.

(*b*) Contour trenching.

(*c*) Cho training.

(*d*) Terracing and watbandi.

(*e*) Sowing and planting.

(*f*) Reclamation of eroded lands and cho-beds.

(*g*) Closures and demarcation.

(*h*) Working plans and utilization.

All these works done combined have given excellent results as expected. On account of financial stringency the tendency in later year has been to give preference to vegetation over engineering works. Experience has shown that not only is the new method cheaper but also more effective in the long run.

These principal features of the schemes as well as the extent of expenditure required to carry out the works in the Province were discussed with Dr. Gian Chand during his visit last year. The total estimate of the works required to be done may be taken at about 5 crores of rupees, but this estimate must vary not only according to the labour rates prevailing in the country but also on the prices of food stuff prevailing at any time because works such as levelling and terracing of land are entirely an economic proposition, what may look a paying proposition to-day may not be worth-while when the rates fail. So various estimates have been prepared at different times but when the Post-War schemes were first brought out, the schemes was estimated to cost rupees 50 lacs. The amount spent is given below :—

1946–47 Rs. 1,51,500 (S.G.).

1947–48 Rs. 1,36,840. Do.
from 15–8–47.

1948–49 Rs. 1,95,961.

1949–50 Rs. 4,92,000, approximately.

The soil conservation schemes can broadly be dealt with under two heads :—

1. Mechanized work connected with levelling terracing, etc.

2. Vegetative work.

With regard to the first, it was intended to employ large teams of caterpillar, tractors with bulldozers, terracers, levellers, etc. But actually only a few have been purchased on account of financial difficulty.

The work so far is on a small scale and therefore, not many difficulties have been experienced in connection with staff of the machines. As has been seen already the main work now is connected with covering the hill sides and slopes with trees and grasses, training chos and reclaiming land. No machines are required for this purpose and we have ample competent and experienced staff to do this work. The only difficulty is funds. If these are provided we can go ahead with the job of reclaiming and restoring fertility to cultivated lands.

LANNEA GRANDIS, ENGLER

(Syn. *Lannea woodier*, *Odina wodier*, Roxb.)

BY DR. K. KADAMBI
(*Assistant Silviculturist*)

FAMILY : *Anacardiacea*

General.—*Lannea grandis* is a moderate to large sized deciduous tree according to habitat with an ashy coloured, thick, scaly outer bark exfoliating in irregular rounded plates and a mucilaginous inner bark which, on blazing, looks bright crimson streaked with pale pink or white. It is a handsome tree when in full foliage but often an eyesore when leafless. In the dry forests of Madhya Bharat, Madhya Pradesh, Deccan and Carnatic it is a moderate sized tree generally 4 to 5 ft. in girth and attaining a girth of 7 ft. in favourable localities with a 10 to 15 ft. long cylindrical bole. In the moister forests of the Western Ghats (Kanara, Malabar, Coorg and Travancore), in the sub-Himalayan tracts of Bengal and Assam and in Andamans and Burma the tree attains girths of 8 to 10 ft. with straight cylindrical boles about 40 feet long ; it attains girths of 12 ft. in the Gonda forests of Oudh (U.P.)[1] and 15 feet in Travancore. Kurz has given the dimensions of the tree in Burma as : height—30 to 60 ft., length of clean bole—15 to 40 ft. and girth—3 to 10 ft. In the drier forests the percentage of heartwood is said to be very small amounting to 30 per cent of the log volume, but in moister forests it forms 40 to 50 per cent of it[2]. The wood is used for a great variety of purposes, and the bark yields a useful gum. It is a good fodder tree. It is often grown as an avenue tree but has the disadvantage of being leafless in the hot season.

Local names[3].—*Kiamil, kimul, kaimal, kamlai, kashmala, jhingan, mowen, mohin, moyen, mowai, moyna, ginyan* (Hindi) ; *gunj* (Bundelkhand) ; *jigna* (Oudh) ; *bara dabdabbi, halloray, halure* (Nepal) ; *jia, jiyal, lohar, bhadi* (Bengal) ; *gob* (Ajmere) ; *gol* (Merwara) ; *maredo* (Kathiawar) ; *wodier, odiyamaram, woodthia, wude, uthi, odi, odayan* (Tamil) ; *gumpini, oddhi, gumpina, gumpna, gumpan, dumpini, dumpri, dumper* (Telugu) ; *kaikra, gumpri, gharri* (Gondi) ; *kekeda* (Kurku) ; *shimti, punil, gojal, godda, goddamte, gugul, geru* (Kannada) : *moi, moja, moye, moyen, shimbat, shembat, shimti* (Marathi) ; *wothi, kalasan, annakara* (Malayalam) ; *poma, tharibe, jia, jika, zikkah, madabai* (Assam) ; *moi, doka, doke, dope, jial, parmi, genjan, kekat, nanam* (Bihar and Orissa) ; *nabe, hnabe* (Burma) : *pranglasi* (Kochin) ; *nanun* (Andamans)[4].

Botanical description.—*Odina wodier*, Roxb.[5] (Syn. *Lannea grandis*, Engler.)—Trees with few stout soft branches, bark exfoliating, young parts clothed with stellate down. *Leaves* few at the ends of the branches, alternate, odd-pinnate, deciduous 12–18 in., petiole terete ; leaflets 3 to 5 pairs, opposite petiolulate, quite entire 3–6 in., oblong obovate, caudate acuminate. *Racemes* simple and panicled, terminal, fascicled, slender ; ♂ compound, ♀ simple pubescent. *Flowers* small, monœcious or diœcious, fascicled, shortly pedicelled, 4–5 merous, shortly cymose, inodorous ; bracts ciliate. *Calyx* 4–5 lobed, persistent, obtuse, ciliate ; lobes rounded, imbricate. *Petals* 4–5 imbricate, twice as long, oblong, spreading, purplish (pink : Brandis) and greenish yellow, Disk, annular, 4–5 lobed. *Male flowers*—*stamens* 8 to 10, equalling the petals, inserted within the 8-lobed disk, rudimentary, ovary 4–5 parted. *Female flowers*—*ovary* sessile, oblong, 1-celled ; styles 3–4, short, stout, stigmas simple, or capitate, stamens rudimentary, sterile. *Drupe* red, reinform, oblong, ½ in. long, stone hard (Brandis).

Distribution and Habitat.—The tree is distributed almost throughout the hotter parts of India, Burma[6], Andamans and Ceylon. From the Indus (Beas) in the North-West it extends along the lower Himalayas and ascends the valleys up to about 4,000 ft. In the sub-Himalayan zone it is found in sal forests as far as Assam and in the mixed deciduous forests of the plains and outer hills. From the *tarai* and *bhabar* tracts it extends down through Bihar (Chota Nagpur) and

Orissa through Madhya Pradesh to the Deccan Peninsula, where it is found scattered throughout in the moist-deciduous forests (Fig. 1). It is often planted in avenues[7].

The tree is found throughout the plains of Uttar Pradesh[8] but is more common in the divisions Gonda, Kheri, Lansdowne, Kalagarh, Ramnagar and Haldwani, where it also attains best dimensions. In Gonda it is found in Tulsipur forest and attains here girths of 7 ft. and has a clean bole 40 ft. long. It is common throughout Kheri division in all types of forest, sometimes in mixture with sal, at elevations of 500 to 600 ft. It is found sparsely scattered throughout Lansdowne division up to 3,000 ft. It is fairly common in the open low-lying forests of Ramnagar division and ascends up to 4,000 ft. in the hills, prefering the hot, sunny aspects. In Haldwani division it is common throughout the foot hills and *bhabar* areas. It has been mostly cut out of the sal forests where it existed. It is fairly common throughout Jhansi division, but moderately so only in the northern and central parts of Gorakhpur division. In the Siwaliks it is rarely found in sal forests of the northern slopes, but ascends in the mixed forests up to 2,500 ft. on the southern slopes.

In East Punjab the tree occurs scattered in the forests of Kangra and Hoshiarpur divisions and also ascends along the valleys into the hills.

In Bengal it occurs throughout the Jalpaiguri and Buxa divisions in the sal and mixed forests but is nowhere abundant. It is fairly common in the mixed forests of Kalimpong division up to 3,000 ft. but in the forests of Kurseong division it occurs sparsely distributed up to 2,000 ft. In these divisions it attains girths up to 8 ft. with clean boles from 25 to 40 ft. high.

In Assam the tree is very scarce and cannot be said to occur in commercial quantities anywhere. It is found only in the *bhabar* and *tarai* region of lower Assam and extends sparingly into upper Assam.

In the states of Bihar and Orissa the tree does not attain large dimensions and occurs in practically all the divisions in dry forests. It is found scattered throughout the Santal Parganas division. In Sambalpur and Singbhaum it occurs scattered in the dry mixed forests. In Chaibassa it is found scattered in the hill forests and forms about 5 per cent of the growing stock. In Palmau it occurs commonly scattered in the dry hill forests of Kodarma and Palmau. In Angul it is common throughout the division especially on the drier hill slopes. Throughout Puri division it is fairly common in both sal and mixed forests and ascends up to 3,000 ft. In Sambalpur it attains only a girth of 4 ft. with a clean bole of about 15 ft.; in Palmau and Chaibassa it attains a girth of 5 ft., and in the remaining four divisions mentioned above it attains a girth of 6 ft. with boles 15 to 20 ft. long. In Ganjam it is common on inferior plains soil chiefly on hills sides but it cannot compete with sal on better soils.

In Madhya Pradesh the tree generally attains a small size except in the hills where, on shady slopes, it may attain a girth of 6 ft. It is found in all the divisions. It is common or sometimes very common throughout the divisions Damoh, Jubbulpore, Narasingpore, North and South Mandla, Chhindwara, Hoshangabad, Betul (1,200 to 2,500 ft. altitude), North Chanda, Bhandara and Bilaspur. It is fairly common in the divisions Saugor, Seoni and Akola (Balapur, Morna and Pangra forest ranges). In Nimar division it is found in Khandwa, Kalibhit, Punasa and Burhanpur ranges. In Buldana division it is found in Geruwatergoan, Aurdari and Ambarwa reserves between elevations of 900 and 2,500 ft. In Yeotmal division it is common in teak forests between altitudes of 1,000 and 1,500 ft. In Balaghat division it is found throughout the mixed forests, especially in Pareswara, Dhansur and Lanji ranges. In Nagpur–Wardha and South Raipur divisions it occurs scattered in the East and West Pench ranges of the former division and throughout the latter division, where, however, it attains good dimensions in South Sihawa range only.

The tree is common throughout the moist-deciduous forests of Bombay state[9] but attains best dimensions in the Kanara forest divisions. In North Khandesh it is common throughout the division. In East Khandesh it is found in the teak and deciduous forests at 500 to 2,500 ft. elevations. It is found fairly commonly scattered throughout Belgaum except on the Ghats and sparsely scattered throughout the more open jungles of North Kanara. In Panch Mahals it is found in the ranges Goelhra, Kala, Halal and Dohad. In East and West Kanara divisions it is common in deciduous

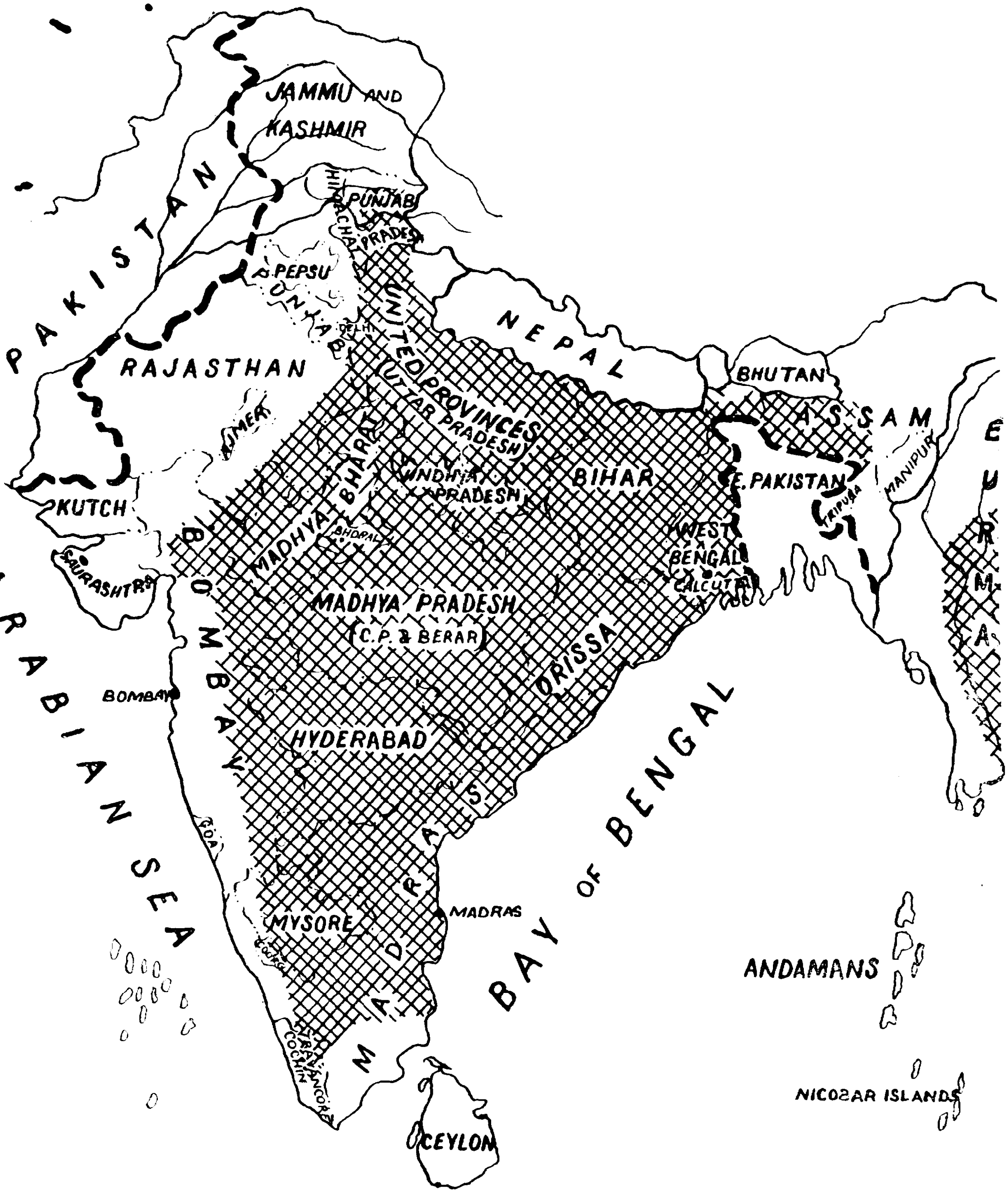

FIG. 1.—Map showing distribution of species.

FIG. 2.—*Lannea grandis* Engler.
Photo R. P. Bahuguna 1931.

forests. In Central Kanara it is found scattered in the ranges Ankola, Kumta and Sissi, and in South Kanara in the Bhatkal, Honavar, Kumta and Siddapur ranges, attaining large dimensions (7 ft.) in the Suppimbosalli forests.

In Madras state[10] it is found throughout the dry deciduous forests, but is commonest in Godavari and Kurnool divisions on the east coast and Coimbatore and Mangalore divisions on the west coast. It is also common in Upper and Lower Godavari, East and South Kurnool, South Malabar and South Mangalore divisions. In Lower Godavari it is found chiefly in Sudikonda, Irrumalayapalem and Mallavaram reserves. In West Kurnool it is common in Nandi–Kotkur and Nandyal reserves and occurs scattered in Nallamalai hills up to 2,000 ft. In Coimbatore it is found on the lower slopes of Nilgiris between 750 and 2,000 ft. and in the better class deciduous forests in Kallar, Walayar and Chenat Nair reserves and in Bolampatti valley. In North Malabar it occurs in the teak mixed high forests of the Wynaad at elevations of 2,300 to 3,000 ft.

In Coorg it is common throughout the deciduous forests, while in Mysore state[11] and the Travancore-Cochin states union it occurs scattered throughout the moist and dry deciduous forests. It attains girths of 8 ft. in Coorg, 5 to 7 ft. in Mysore depending upon the locality, and 10 to 15 ft. in Travancore.

In Burma the tree is fairly common but scattered throughout the mixed deciduous forests, but attains best dimensions in the mixed deciduous forests of Pyinmana division in Yamethin district. It is fairly common to common in the divisions Thayetmyo, Prome, Tharawaddy (in the Yomas and plains), Henzada–Maubin, Myitkyina, Katha, Mu, Upper Chindwin, Mandalay and Yaw. It is scarce or scattered in the divisions Insein, Bassein–Myangyna, West Salween, Thaungyin, Nyaunglebin, Bhamo, Myittha, Ruby Mines, Southern Shan States and Minbu, in moist or dry forests. In South Toungoo it occurs in semi-evergreen forest. In Meiktila division it is very scarce.

Its habitat is the moist deciduous forests of India, of both the moist and the dry types, but especially of the latter type, while in Burma it is common both in the Upper and Lower mixed forests. In the drier types of forests found in Central India it attains but meagre dimensions, with girths of 2 to 3 ft. and clear boles 10 to 14 ft. high, but its size increases with improving forest quality towards the south of the Deccan peninsula, where it attains its best sizes in India. Sizes of 12 ft. are also sometimes attained in the other moist localities in India like Haldwani in Uttar Pradesh, portions of Bengal and West Kanara, South Mangalore and Coorg in South India. Where it meets with more moisture it develops into a handsome tree with a fine spreading crown (Fig. 2), and produces really valuable heartwood.

In the dry forests of Madhya Pradesh, Khandesh and the Deccan peninsula it is associated with the species *Boswellia serrata*, *Anogeissus latifolia* and other fire resistant species; in fact *Lannea grandis* feels quite at home in such forests, though it occurs commonly in the more moist types and, rarely it enters even semi-evergreen forests, as in the South Toungoo division of Burma. The fact that it is one of the species which has been used with success in reclaiming the sandy waste in Tinnavelly district, along with other xerophytic species like *Borassus flabelliformis* (the Palmyra palm), *Acacia planifrons*, *Dalbergia spinosa* and *Anacardium occidentale*[3], indicates its drought resisting capacity. For reclaiming sandy wastes branch cuttings of *Lannea grandis* have been used. It has also been planted with success in connection with the scenic afforestation of the Chamundi hill, a dry rocky hill adjoining Mysore city. In its natural habitat the absolute maximum and minimum temperatures vary from[12] 100° to 118° F and 30° to 60° F respectively and the normal rainfall from 25 to 150 inches.

Generally speaking the tree avoids the very moist regions like the evergreen forests of the Western Ghats, but on the other hand it does not extend into the driest parts of India, being absent from most parts of Rajputana; in the drier regions its habit is sometimes stunted and crooked, though this condition is often partly due to fire and maltreatment.

It grows on a variety of geological formations, including sandstone, limestone, metamorphic rocks, trap and sometimes laterite. It attains its largest dimensions, however, on well drained, deep alluvial or diluvial soil. It avoids swampy and badly drained soil and

prefers good drainage. In Burma it exists on permeable siliceous sandstone[6].

Leafshedding, flowering and fruiting.—The tree is typically deciduous. It commences to drop its leaves in November and is almost entirely leafless by the end of December or January, and remains so till May–June. Though leafless as a rule from January to June, on the east side of the Deccan peninsula (Sriharikota, Madras and Javadies) it is stated to retain leaf almost throughout the year[4]. The flowers appear when the tree is entirely leafless, about February, in stiff terminal racemes at the ends of branches. The height of the flowering season is March–April (February–March in Burma) when the trees are covered with masses of feathery whitish blossoms and present a handsome appearance. The drupe begins to form almost immediately thereafter and attains nearly its mature size before the leaves reappear ; it ripens from May to July and remains fairly long on the tree (September–October in Burma). Fruit formation is abundant and crows are said to be fond of it[3]; they swallow the pulp surrounding the seed along with it and throw out the skin.

Silvicultural characters.—The tree is a pronounced light-demander. Kurz[6] calls it a light-loving tree. It is decidedly frost-tender, quite drought and fire resistant, pollards well, produces root-suckers and coppices freely. In its own habitat its natural regeneration is generally adequate. It can also be artificially regenerated with comparative ease either by planting nursery raised stock or branch cuttings.

In Dehra Dun, seedlings planted in the open are frosted back each year but are replaced by fresh shoots in the next growing season. In the severe frost of 1905 the tree suffered much in Northern India[12]. It was only slightly affected by the excessive drought of 1899 and 1900 in the Deccan, and proved to be decidedly drought resistant in the abnormal drought of 1907–08 in Oudh. Its drought resisting power is illustrated by its occurrence in the dune forests found in Teknaf range of the Cox's Bazar division (East Pakistan) on calcareous sand along the seashore, where it is found along with species like *Pongamia glabra* (*karanj*), *Sterculia alata* (*tula*), *Morus lævigata* (*bola*), *Erythrina suberosa* (*madar*) and *Casuarina equisetifolia* (*jhau*)[13]. It is also one of the species found quite suitable in reclaiming the sandy desert called Kudirai Mohteri near Tinnavelly. A. E. Osmaston has observed in his experiments of 1909–10 in the Gorakhpur forests (Uttar Pradesh) that of 18 trees felled none produced coppice shoots[14]. Troup has remarked in this connection that the abnormal years of drought which preceded the operation may have adversely affected the vitality of the stumps and consequently also their coppicing power. It is, however, more likely that the trees were coppiced at the height of the dry and hot season, resulting in the death of the cambium thus suddenly exposed to the sun, a phenomenon which has been frequently noticed by me in some parts of the Deccan. Measurements made by C. M. McCrie in Gorakhpur forests showed an average of 3, 2, 1 and 1 shoots per stool in the case of coppice 5, 7, 13 and 15 years old respectively, while measurements made by R. S. Troup, in one year old coppice, in Tikri forest, Gonda (Uttar Pradesh), showed an average of two shoots per stool[12].

Natural regeneration.—The seed crop of *Lannea grandis* is generally good in various parts of India, but information is meagre about its natural regeneration by seed. In mixed deciduous forests natural regeneration is adequate though not abundant. Its coppicing power is generally good ; trees coppiced in June 1919 in Burma threw out within a year coppice shoots up to 10 feet high.

Artificial regeneration.—The tree can be reproduced artificially with comparative ease, either by sowing seed broadcast after felling and burning the natural forest (Burma), or by putting out entire transplants, stumps or branch cuttings.

In Uttar Pradesh the seed is collected in May–June. 160 fruits and 270 seeds weigh to the ounce. The germinative capacity is not high, being about 43 per cent. In Dehra Dun germination has been found to start in about 10 days after sowing and lasts up to 24 days. In Madhya Pradesh at Tapti the seed is collected in May ; in one case 160 seeds weighed to the ounce and the germinative capacity was found to be 65 per cent. Germination commenced in 6 days after the sowing and lasted up to 12 days. The seed does not keep well. The tree is easily propagated by seed, but the

seed must be sown fresh as it rapidly loses viability. In Saharanpur *taungyas*, sowing done in lines after clear-felling and burning the natural forest and ploughing up the area, along with a field crop, has given fairly satisfactory results. In the Taungunlazau *taungyas*, Twonte range, Insein division of Burma, the species was successfully regenerated by broadcasting the seed after clear-felling and burning the area, and the plants reached heights of 12 ft. in one year, but there were many gaps. In the Hteinmilazur *taungyas* its growth was rather irregular but the plants were looking sturdy, while in the Peinmilazur *taungya* it came up indifferently. In Uttar Pradesh sowings made between the 15th and end of May are reported to have failed completely or produced an odd plant or two. The rapid loss of viability of the seed coupled with its fairly low initial germinative capacity probably accounts for these, rather conflicting, results. If suitable precautions are taken to eliminate adverse influences, there is little doubt that the tree can be propagated without difficulty by sowing. Experiments at Dehra Dun to determine whether one year old nursery stock of *Lannea grandis* of suitable size can be successfully grown by planting in pits with bare roots, on lines cleared through low forest growth so that the plants have side shade but suffer from root competition, showed that the species cannot be satisfactorily propaged under such conditions ; 35 per cent of the plants survived after 4 seasons and had an average height of 24·6 inches. Experiments to determine whether nursery stock of suitable size can be successfully planted out in pits in the open with bare roots and no care other than routine weedings showed that this method can give satisfactory results. The plants were of different sizes and varied from 1 month to 13 months old. They were planted in standard pits spaced 2 ft. apart in lines 4 ft. apart. The following results were obtained :—

	1932 experiment			1933 experiment			
	1932	1933	1934	1933	1934	1935	1936
Survival %	90	71	64	98	96	95	95
Average height (in.)	4·0	7·8	6 to 36	6·2	15·5	38·2	72·5

Also the results indicated that one year old plants are more suitable than are month old ones for transplanting. Experiments to raise the species in the open by planting one year old stumps raised in the nursery from local seed in pits were also very successful and gave the folowing results. The plants had an average unpruned height of 2 ft. 6 in. at the time of preparing the stumps, and they were pruned down while planting to have 1½ in. shoot and 9 in. root. Routine weedings were done.

Lannea grandis : Results of stump planting

	1931	1932	1933	1934	1935
	Heights in feet				
Average height ..	7·6	17·5	23·8	36·9	46·4
Survival %	100	89	90	87	89

The tree can be easily propagated by branch cuttings. To ensure success by this method the cuttings, about as thick as a man's arm and fairly long, should be planted firmly in the ground by packing the earth well around them. They should be put out in March–April, when the trees in the natural forest would not have yet sprounted. Branches which are two to three years old generally succeed better than older ones. Successful planting of cuttings has been reported from the Northern Circle of Madhya Pradesh state and elsewhere. In Burma planting cuttings in March–April has been recommended and cuttings are planted successfully by villagers to serve as a live-hedge. In Mysore trees of *Lannea grandis* of 9 to 18 in. mid-girth uprooted from natural forests and planted on the top of the Chamundi, a dry rocky hill, in 2 ft. cube pits during April–May, after cutting the shoot portion to a height of 7 to 8 feet and trimming the main roots to a length 1 to 1½ feet, gave satisfactory results. The altitude at the planting site is about 3,000 ft. and the annual rainfall about 25 inches. The method has been called "Tree stumping".[15] In view of the cost and labour involved this method can only be recommended under special circumstances when scenic afforestation has to be done irrespective of the cost.

Management.—Wherever it occurs in India, *Lannea grandis* being an accessory species, no specific silvicultural treatment has been prescribed in the existing working plans towards the encourgement of this tree. In the sub-Himalayan zone, where it occurs in the sal

forests, it has been cut out in some places during the improvement or regeneration fellings done for sal. In the teak and non-teak moist deciduous forests of Central and Southern India its management method is governed by the condition of the forest where it is found, being uniform, selection, coppice with standards, coppice with reserves or simple coppice. Where improvement fellings are done, *Lannea grandis*, where it occurs, is cut out to make room for more valuable trees like teak, rosewood, *Pterocarpus marsupium*, etc. The exploitable girth of the tree varies within wide limits according to the locality, type of forest and method of management. The following information on the exploitable girth fixed for the species in different Indian states is available :—

Lannea grandis : Exploitable girths in different states.

State	*Forest division*	*Girth*
Uttar Pradesh	Haldwani, Kheri, Gonda, Lansdowne	6 feet.
Bengal	Jalpaiguri, Buxa	6 feet.
	Kalimpong	7 feet.
Orissa	Puri	5 feet.
Madhya Pradesh	Yeotmal	2 feet.
	Hoshangabad, South Mandla, Nagpur-Wardha	3 feet.
	Seoni	Over 3 feet.
	North Mandla, South Raipur	4 feet.
	Bhandara	6 feet.
Bombay	North Kanara	5 feet.
Madras ; Coorg and South India	Upper Godavari	3½ feet.
	South Malabar	4 feet.
	Coorg	6 feet.
	Mysore[7]	5 feet.

External dangers and protection.—*Lannea grandis* can resist fire well. It is also decidedly drought resistant being only slightly affected by excessive drought. In Dehra Dun seedlings in open nursery beds are frosted back to ground level almost annually but send up fresh shoots in the ensuing growing season. Stumps planted in the experimental garden, New Forest, Dehra Dun, are sometimes damaged by rats. There are no serious insect pests on the tree. In Burma, the Bostrychid beetle *Heterobostrychis aequalis*, Waterh., bores into newly felled timber and in India this as well as other borers of felled wood like *Xylodectes ornatus* and *Trogoxylon spinifrons* are known to attack green logs and converted timber[16]. *Plocœderus obesus*, another Cerambycid beetle, also frequently attacks felled timber, though not the living tree. The larva of this insect pupates inside the wood in very wide galleries sometimes 6 inches deep from the surface.

Rate of growth.—Statistics of the rate of growth are scanty. Measurements of one tree extending over 19 years in Ramnagar division. Uttar Pradesh, showed a mean annual girth increment for the period of 0·32 in. The following other measurements have been recorded by Troup :—

1. Age of tree : 73 years ; girth 3 ft. 9 in. ; mean annual girth increment 0·62 in.
2. Age of tree : 49 years ; girth 3 ft. 10 in. ; mean annual girth increment 0·94 in.

The following statistics of the increment of *Lannea grandis* in Burma are available :—

Lannea grandis : Girth increment data in natural forest, South Hlaing Yoma reserve, Insein division.

No. of trees	*Average annual increment over a period of 5 years*
21	0·468

Lannea grandis : Girth increment in different forest types, Insein division[17]

Lower mixed-deciduous forest			Upper mixed-deciduous forest			
No. of trees	Annual girth increment over a period of 3 years (inches)	Annual girth increment over a period of 5 years (inches)	No. of trees	Annual girth increment over a period of 2 years (inches)	Annual girth increment over a period of 3 years (inches)	Annual girth increment over a period of 5 years (inches)
4	0·38	..	11	..	0·38	..
..	..	..	2	0·25	..	..
4	..	0·35	14	..	..	0·28

Girth increments in Magayi and South Hlaing reserves; Insein division[18]

No. of trees	Annual girth increment over a period of					
	5 years			10 years		
	Max.	Min.	Average	Max.	Min.	Average
		(inches and decimals)			(inches and decimals)	
20	1·16	0·06	0·48	0·95	0·01	0·39

The rate of growth of coppice is fast. The following coppice measurements made by C. M. McCrie have been recorded by Troup :—

Lannea grandis : Coppice measurements, Gorakhpur, Uttar Pradesh.

Age	Mean height (feet)	Mean girth (inches)
2	5·8	2·3
4	10·9	4·1
6	14·2	5·8
8	16·7	7·3
10	19·0	8·6
12	21·1	9·8
14	22·9	10·8
16	24·3	11·5

Troup's own measurements in one year old coppice coupes in Tikri forest, Gonda (Uttar Pradesh) showed an average height of 5 ft.

The following girth increments of coppice shoots from fellings of 1904–05, measured by Ranger T. V. Arunugam Pillai in December 1911 in Thampurattipottai reserve, Palghat division, are on record.

Lannea grandis : Girth increment of coppice shoots.

No. of shoots measured	Average girth of shoots in 7 years (inches)	Mean Annual girth increment (inches)
8	16	2·3

Utilization.—Timber (i) *General characteristics of the wood*—Sapwood very wide, white or yellowish-white, turning light brownish-grey and then sometimes with a purplish cast, very wide ; heartwood light pinkish-red or light-red, turning darker-red or brownish-red with age, small, rather lustrous, working smooth, without characteristic odour or taste, light to moderately heavy, straight—or narrowly interlocked—grained, medium–and even–textured.

Anotomically the wood is featured by abundant tyloses in the vessels of the heartwood, sparse parenchyma, septate fibres and horizontal gum canals in the rays.

(ii) *Supplies.*—Accurate figures of yield are wanting. But, in view of its wide distribution in India the total annual supply of this timber is probably large. The supply has been estimated as follows :—Each division of Uttar Pradesh 5,000 c. ft. ; Bihar 5,000 c. ft. ; Orissa 5,000 c. ft. ; East Khandesh 40,000 c. ft. ; Panch Mahals 75,000 c. ft. ; East and West Kanara divisions 75,000 c. ft., Madhya Pradesh from 2,500 to 25,000 c. ft. per division ; Madras 2,500 to 30,000 c. ft. per division ; Mysore 2,500 c. ft. It is estimated that Burma could supply at least 50,000 c. ft. annually.

(iii) *Mechanical properties.*—The weight of sapwood at 12 per cent moisture content is is 36 lb. per c. ft.[19] L. N. Seaman has given its weight as 25 lb./c. ft. and Gamble's figures range between 35 and 60 lb. per c. ft. Troup has given its weight as 50 lb. per c. ft. The greatly varying soil and climatic conditions over its wide range of distribution partly account for this difference. Seaman has probably taken the sapwood only while Gamble has perhaps taken both sapwood and heartwood

separately. The heartwood is fairly strong and moderately hard and close grained. Kann has given the following strength figures for the wood[3] :—

Species	Transverse strength		Crushing strength parallel to grain in lb. per sq. in.
	Breaking strength in lb. per sq. in.	Young's modulus	
Lannea grandis	12,385	1,319,000	8,175
Comparative figures for Burma teak ..	14,465	1,380,000	8,350

Limaye has given the following safe working stresses for the species[20] :—

Locality from where tested	Wt. per c. ft. at 12% moisture content ; lb.		All grandis	Working stress in lb. per sq. in. for standard grade (structural No. 2)											
			Modulus of elasticity 1,000 lb. per sq. in. all locations	Bending & tension along grain			Shear		Compression						
				Extreme fibre stress			Horizontal	Along grain	Parallel to grain			Perpendicular to grain			
				Inside locations	Outside locations	Wet locations	All locations	All locations	Inside locations	Outside locations	Wet locations	Inside locations	Outside locations	Wet locations	
Lannea grandis ..	Dehra Dun ..	35	800	1,200	1,000	800	90	130	700	600	500	320	250	200	
Comparative figures for teak	S.W. Burma & East & South India	42	1,600	2,300	1,950	1,550	140	200	1,500	1,300	1,100	630	490	400	

(iv) *Seasoning properties* .—Opinions vary on this point. Cox has stated that the seasoning of this timber presents no particular difficulties provided proper care is taken to prevent decay and staining. Pearson and Brown have said that it is a difficult timber to season, not so much because the heartwood splits, but because it takes longer to season than any other Indian timber. In Dehra Dun it was found that the timber kiln-seasons well in a water spray kiln, but that unless it is in small dimensions its seasoning is hardly a commercial proposition.

(v) *Durability and adaptability to treatment.*—The sapwood is liable to rapid decay and borer and white-ant attacks, so that the logs should be converted as soon as possible after felling and the material piled in a well ventilated place protected from sun and rain. In Burma, the heartwood is considered better than the wood of *Dipterocarpus tuberculatus* and is said to last 15–20 years[1]. Pearson and Brown have stated that out of 3 B.G. sleepers, which had been treated by the Powell process and laid in the Bombay, Baroda and Central India Railway line, inspection after 12½ years showed that two were virtually sound, and the third badly cracked ; all contained sapwood, one of them having 80 per cent sapwood. The wood lasts well under water and is said to be durable under cover. Cox says that the heartwood is occasionally passed off as *Xylia dolabriformis* in Burma.

Working qualities .—The timber is easy to saw, work and turn. It can be worked with care to a beautiful finish, and takes a high polish, which brings out the grain.

(vi) *Uses, present and prospective.*—*Lannea grandis* is a commonly used timber. It is used for house building (chiefly planking), common furniture, packing cases, plough shafts, water pipes, water troughs, well construction, dug-out canoes, ribs and helms of boats, combs, bowels, wooden jars, carving, turnery, coopers work, mine props (Mohpani colliery, Madhya Pradesh), matches (Madhya Pradesh), cutting blocks, boot-trees and brush backs and handles (Bareilly, Uttar Pradesh). It is also used for spearshafts, scabbards, wheel spokes, cattle yokes, oil and sugarcane presses and rice pounders. Gamble says that it has been tried for sleepers both in Madras and on the Oudh and Rohilkhand railway but proved unsatisfactory. The wood is not considered as good fuel in Madras though often used as such. In the Chittagong hill tracts the timber is used for general house purposes and appreciated as a good timber. In Khandesh the Bhils are said to use the heartwood for hut posts. It is commonly used also in Burma for house posts. The heartwood has been used for pencil making in Madras. It has also been suggested for rollers in jute mills. In Merwara, ornamental boxes, letter racks and paper stands are made of it. The fine grain of its heartwood is said to make it particularly suitable for delicate carving. Cox says that in Kurseong (West Bengal) the timber has been tried for tea boxes but has been objected to on account of its hardness; it is, however, stated to be occasionally passed off as toon by the dealers and all available supplies in Jalpaiguri and ...ca are reported to be used locally for tea ...xes. It is one of the principal species used for plough-shares in Cox's Bazar division (East Pakistan). The timber is also indicated to be suitable for cask making[1], and to make wood-pulp of somewhat inferior quality but good bleaching power. It is also stated to be 'very good' for matches and good for inside match boxes, but not for outside boxes. Pearson and Brown have concluded that the timber of *Lannea grandis* has so many inherent good qualities that it deserves further thorough investigation.

(vii) *Destructive distillation.*—The wood of *Lannea grandis* from Siwalik division (Uttar Pradesh) containing 59·14 per cent of moisture, when subjected to destructive distillation, gave 19·2 per cent of charcoal, 1·17 per cent of tar and 34·37 per cent of crude pyroligneous acid[16].

(viii) *Calorific value.*—The calorific value of the charcoal from the wood of *Lannea grandis* is given in the following table :—

	Calories	B.T.U.	Evaporation power in lb. of water at 100° C. evaporated by 1 lb. of fuel
Open kiln ..	6,378	11,480	11·87
Closed kiln ..	7,247	13,045	13·48

Minor Forest Produce.—The most important minor produce obtained from *Lannea grandis* is the Thingan gum tapped from the tree in the Saharanpur Siwaliks (Uttar Pradesh) and commonly used in India as a mucilage, for making ink and in the finer parts of stucco work, but it is especially useful to confectioners owing to its great solubility in water, and a certain amount is exported from India for this purpose. The gum is a yellowish-brown clear brittle substance and is commonly used by country weavers for sizing cloth ; it is also used for sizing paper and as a medicine. Tapping for gum generally starts in North India in March and continues till the rains break. The usual method of tapping is to make short shallow cuts all over the bark with an axe when the gum exudes in round tear-drops. The yield in the first year is about 5 seers of gum per tree, but at the end of 5 years it is reduced to about 1 seer. Tapping is therefore usually carried on for 5 years and then the trees are given rest to allow them to regain their vitality and their wounds to heal up[21]. Gamble notes that samples of the gum were examined at the Imperial Institute in 1895 and found to be soluble in twice their weight of water and to have about $\frac{3}{4}$ the viscocity of gum arabic[22]. In Madras the gum is commonly used for mixing with lime for white washing and plastering. In Burma the gum is used as an adhesive and for smearing on fishing nets as a preservative.

Lannea grandis is a good fodder tree, being commonly lopped and often pollarded for this purpose. The fodder is considered specially good for elephants.

The bark contains 9 per cent of tannin and yields a coarse fibre which can be made into poor quality ropes. In Burma the bark, after being well washed and boiled, is commonly

used to form elephant dragging pads. A decoction of the inner bark is often used in the form of a poultice as a remedy for festering wounds, sores or boils while the dried and powdered bark is also used as a tooth powder by villagers.

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BIOLOGICAL NOTES ON *METANASTRIA HYRTACA* CRAM. (LEPIDOPTERA : LASIOCAMPIDAE)

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This is a polyphagous species and is not a pest of economic importance, but occasionally it appears in very large numbers and does considerable damage to the leaves, even of large trees.

Food-plants.—Subramanian and Anantanarayanan (1938) and Beeson (1941) have listed these plants :—*Acacia arabica*, *Achras sapota*, *Albizzia stipulata*, *Anthocephalus cadamba*, *A. morindaefolius*, *Bassia longifolia*, *Bischofia javanica*, *Eucalyptus globulus*, *Eucalyptus* spp., *Eugenia jambolana*, *Guazuma tomentosa*, *Mimusops elengi*, *Nyctanthes arbortristis*, *Schima wallichii*, *Terminalia catappa* and *Terminalia* spp. Other food plants on which this species has been bred are : *Bassia latifolia*, *Elaeocarpus* sp., *Glochidion velutinum*, *Gmelina arborea*, *Morus alba*, *Shorea robusta*, *Terminalia myriocarpa*, *T. paniculata*, *T. tomentosa*.

Distribution.—Assam ; Calcutta, Kalimpong (Bengal) ; Champaran, Pusa, Rajpur (Bihar) ; Bombay, Karwar, N. Thana (Bombay) ; Maymyo (Burma) ; Mandla (Madhya Pradesh) ; Mhow (Madhya Bharat) ; E. Himalayas ; Chingleput, Coimbatore, Ganjam, Madras (Madras) ; Sikkim ; Travancore ; Dehra Dun, Mussoorie (U.P.) ; Ceylon ; Philippines.

Life-history.—A short account of the life-history has been given by Subramanian and Anantanarayanan (1938) and by Beeson (1941). Some observations on its life-history made during 1936, 1938 and 1939 at Dehra Dun, are presented below. This species was collected and bred on *Eugenia jambolana*.

This insect has three life-cycles in a year at Dehra Dun. Two life-cycles are completed in summer and the third is a winter generation. The summer generations had an incubation period of 7 to 12 days, a larval period of 46 to 68 days and a pupal period of 10 to 19 days. The eggs laid in September by the moths of the second generation hatched in October after 12 to 20 days and the caterpillars continued feeding on the leaves throughout winter and spring and pupated sometime in April next. The moths of the winter generation began to emerge in the third week of April and their emergence continued till early May. The larval period in the winter generation occupied 184 to 200 days (about $6\frac{3}{4}$ months) and the pupal period ranged from 13 to 19 days. Occasionally, the larvae of the second generation pupate in September–October and the moths emerge in October–November.

A large series of *Winthemia trichopareia* Malloch (Diptera : Tachinidae) was bred during April and May from the field-collected larvae of 25th March 1936. Another Tachinid, *Sturmia sericariae* Corn., was bred in April 1939, from the laboratory-bred larvae of the winter generation. Gardner (1940) has described the puparium of both the Tachinid flies.

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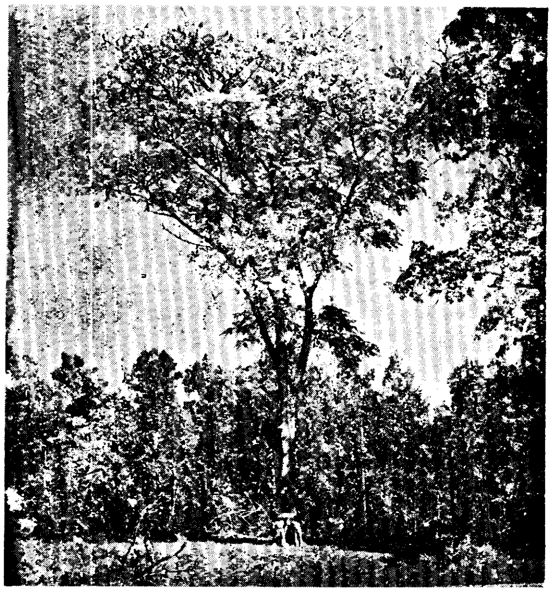
OCCURRENCE OF *MELIA COMPOSITA* (WILLD) IN ALLAPALLI RANGE SOUTH CHANDA, M.P.

C. E. HEWETSON, I.F.S.

When carrying out preliminary felling and burning for the plantations in compartment 60 of the Plains Felling Series in Allapalli we suddenly found one specimen of this tree, and later discovered five or six along the same *nala*. No other specimens have been noticed and it has not been recorded from the surrounding country. It is not given in Haines' list of Trees, shrubs and climbers for the Southern Circle, C.P. In Haines' flora of Bihar and Orissa it is shewn as occurring in Angul and Puri. In Dr. Mooney's Supplement to the above Flora (1950) he does not list it in the districts between Puri and Chanda. In the Flora of Madras by Gamble it is recorded from North Circars, hills of Ganjam and in the Deccan in the Nallamalai hills. In Brown and Pearson they give the same distribution and also shew it as occurring in Assam. In Allapalli these trees are growing at an elevation of about 450 feet above sea-level. The photograph shews the largest tree with an estimated height of 105 feet and girth over 9 feet at B.H. In the adjoining plantation area some natural seedlings were found but normally all regeneration is destroyed by the *cheetal*. The occurrence of such isolated specimens of trees in India is one of the intriguing problems in plant distribution. The possible solutions have been discussed in several interesting papers written by Dr. Mooney.



Allapalli South Chanda, M.P.

Photo Author.